THE ENGINEER

VEMBER 3, 1961 — 28 ESSEX STREET, STRAND, LONDON, W.C.2 — TWO SHILLINGS

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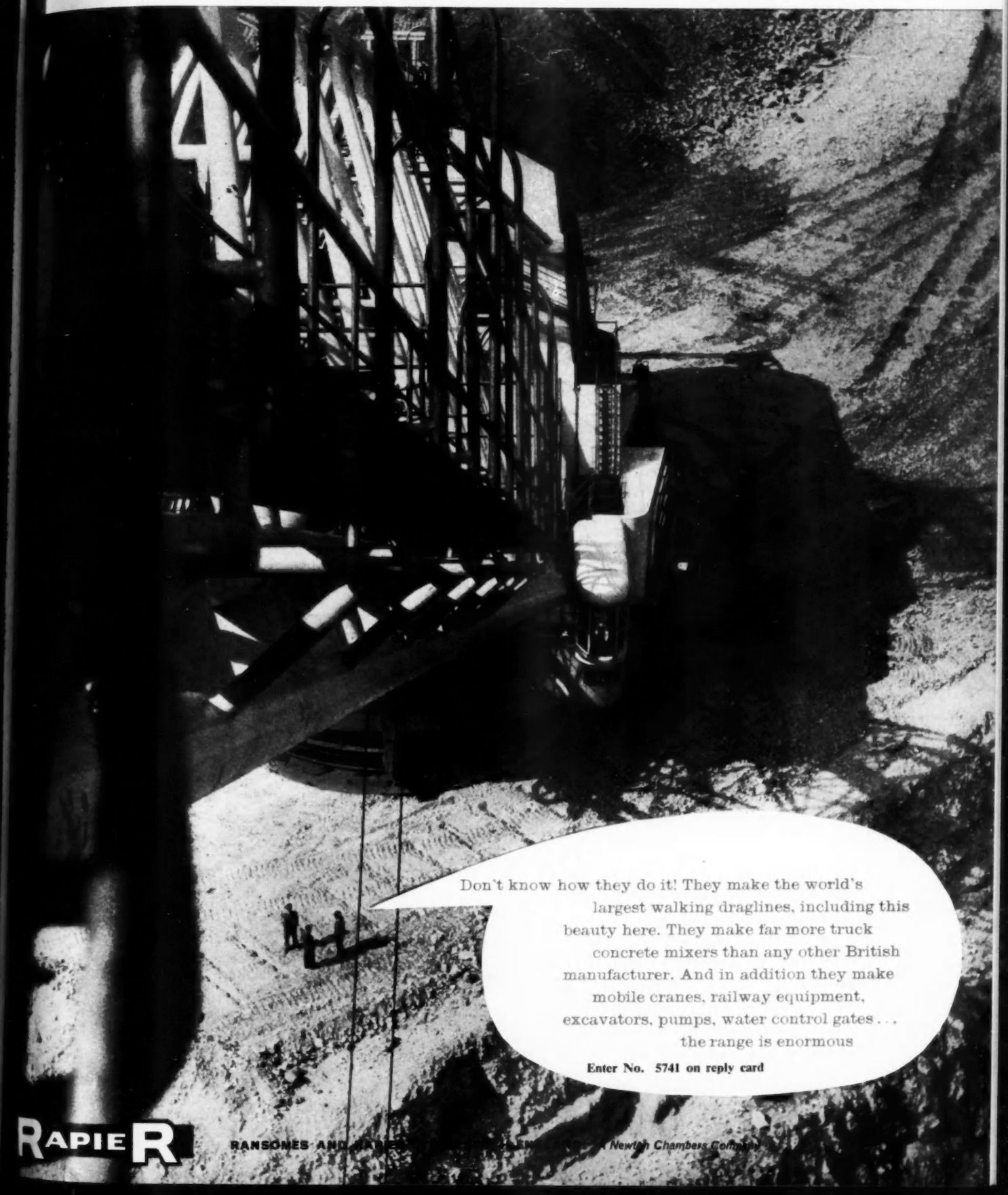

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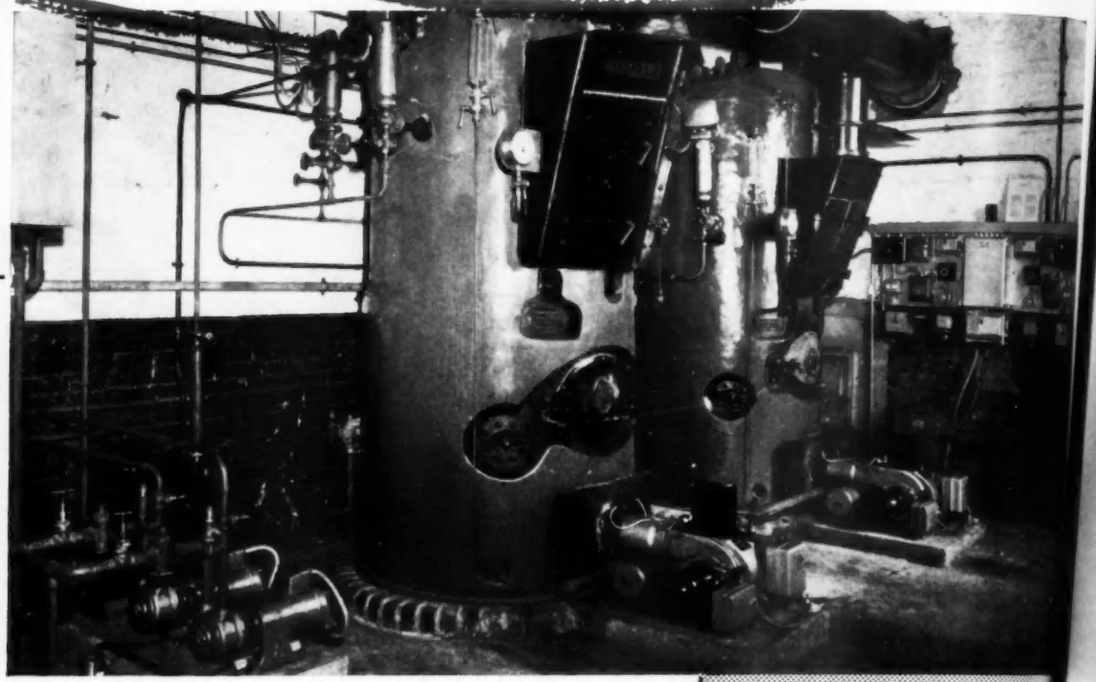

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Flue Gas Temperature	Boiler Exit:	565°F.	590°F.
Shell Smoke Number:		3.	4.
Boiler Efficiency (Gross C.V.)		77%	77%
LOW FLAME			
CO_2 content flue gas	Furnace:	11·5%	11·25%
	Boiler Exit:	9%	8·75%
Flue Gas Temperature	Boiler Exit:	450°F.	480°F.
Shell Smoke Number:		3.	3.
Boiler Efficiency (Gross C.V.)		73·5%	72%

NOTE: The drop in CO_2 content between furnace and boiler exit indicates leaks causing ingress of air.

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No. 5519 NOVEMBER 3, 1961 VOL. 212

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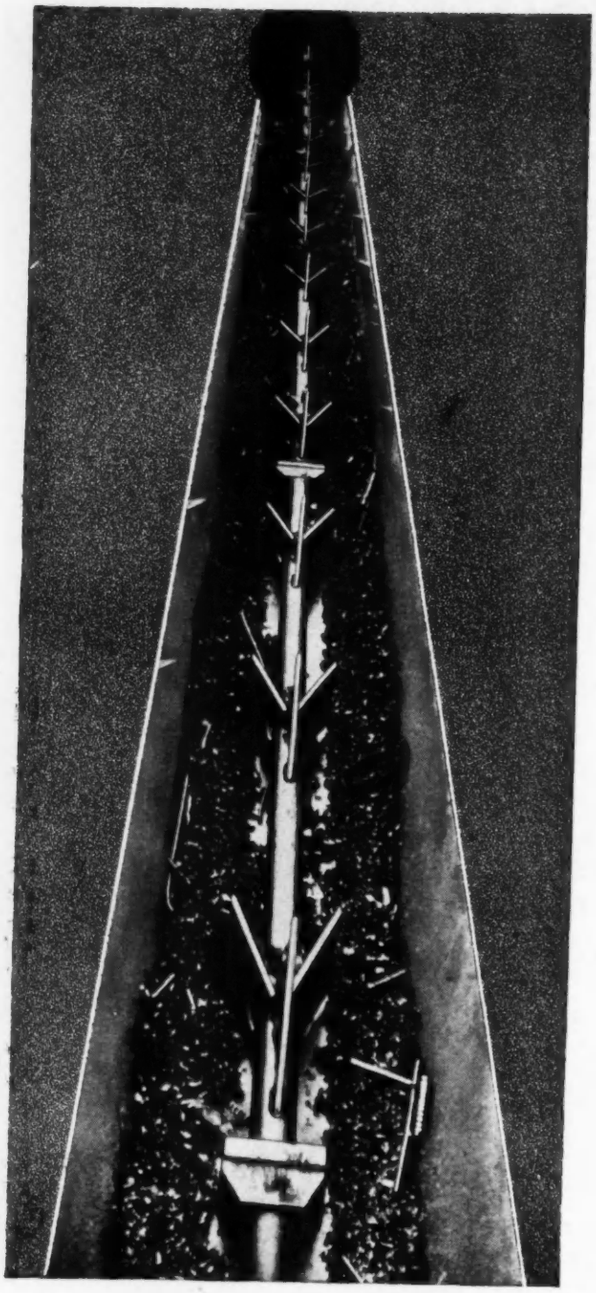

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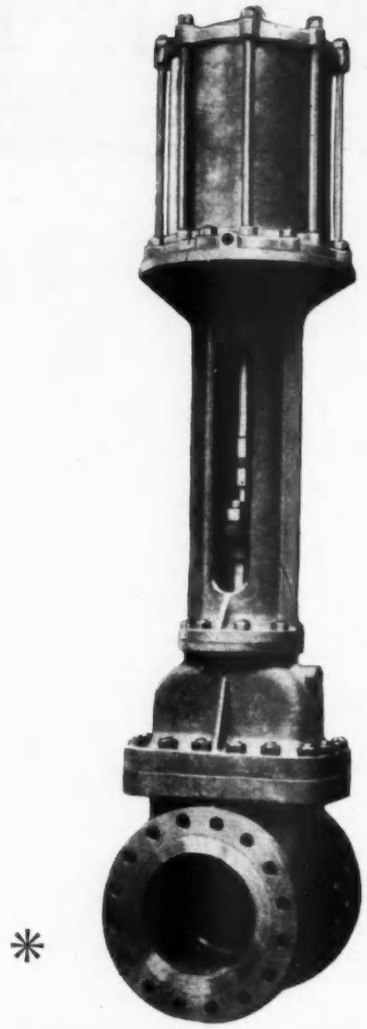

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THE ENGINEER

No. 5519 NOVEMBER 3, 1961 Vol. 212

BRITAIN BECOMING A NET IMPORTER OF SHIPS?

The chartered accountants' inquiry, instigated by Mr. Marples in July, as to why orders for new ships have been placed abroad by British owners, has now been completed, and the report discloses the disturbing fact that in the period January 1, 1959 to July 31, 1961 orders for a total of thirty-four ships for British owners of 199,000 tons gross and valued at £23,000,000 were placed abroad. The ships in question included cargo liners, bulk carriers and deep sea tramps, but no passenger liners or large tankers, and were ordered in Holland, Germany, France, Sweden, Spain and Norway. According to this report tenders were not invited from British yards for seven ships because special circumstances made it appropriate to build them abroad. Tenders from British firms are stated to have ranged between four and thirty per cent above the accepted price except in two instances where there was practically no difference. About half the quotations were between 12 and 17 per cent above those submitted by foreign yards. An analysis of the reasons influencing the decision to build abroad shows that price accounted for fifteen orders, price and delivery for ten orders, and price and credit facilities for six orders. When credit facilities were accepted the report notes that they were not a major influence and no direct evidence was found to indicate that subsidies or other aids played a part in reducing foreign prices.

The report, though it publicly ventilates the matter, actually adds very little knowledge to that already existing within the shipbuilding industry about the situation. Price appears to be the major factor in deciding owners to order abroad; and although no direct evidence was gathered about the use of subsidies and other financial devices to lower artificially the price in foreign yards, the fact that British prices were higher by as much as 30 per cent and that about half were higher by 12 to 17 per cent provides a strong suggestion that certain devices may have been employed to keep foreign prices down. For, now that a majority of British yards have completed extensive conversion schemes so as to be able to build cheaply and rapidly, it requires a great deal of credulity to accept a 30 per cent or even a 12 per cent difference in price without suspecting the presence of a hidden financial factor. Delivery date also plays a significant part in bringing about the signing of a contract and perhaps the operative condition should be written "guaranteed delivery date." In this matter it can be readily understood that British builders are at some disadvantage, for the acceptance of a penalty clause calls for the co-operation of labour in seeing that the ship is delivered by the due date. Unfortunately recent history has shown that this co-operation cannot always be relied upon. Indeed the trade unions involved would probably regard it as not their business but the management's to maintain a delivery date. Although most yards have been comparatively strike free recently there are others in which the opposite state of affairs has ruled. Post-war shipbuilding involves an extensive changeover in production methods from those ruling pre-war, the installation of new machines and the use of new materials. It is undoubtedly the duty of management to keep labour fully informed of pending developments so as to remove any grounds for misunderstanding when changes are made. Nevertheless the unions must give thought to the darkening economic background and soberly face present realities. Modern shipbuilding calls for greater fluidity of labour. Adjustment of the rigid boundaries between trades or, better still, their abolition is clearly desirable. Strikes at the drop of a hat, demarcation and other disputes, and lack of discipline are cankers which need to be removed in the interest of shipbuilding workers themselves, for they all operate against the industry by creating redundancies, throwing schedules out of gear, upsetting delivery dates, and generally putting up costs. This chain reaction closely touches shipowners, who must contrast the uncertainties of production in the home yards with the greater degree of certainty in foreign yards and remember the realities of business. Providing the quality is right (the claim that British quality is the highest in the world is dubious) shipowners will naturally place orders where cost is lowest, and delivery dates are acceptable and assured.

Although the report remarks that credit facilities did not appear to be of primary importance the fact that advantage was taken of them in a number of instances where orders were placed abroad is evidence that credit is available abroad on attractive terms to those owners requiring such facilities. This calls for the examination of what terms are available in this country. Means need to be found to ensure that British shipbuilders are in a position to offer credit on terms as advantageous as those obtainable abroad. The fact that, as pointed out by The Shipbuilding Conference, British yards have booked orders for 72 ships of 243,000 tons gross and valued at £32,000,000 during the period covered by the report, is indicative that the industry is not so far from competitive as the report suggests. Nevertheless a much greater rate in securing orders will be needed if prosperity is to return and the Government should surely not stand idly aside and just await developments. Active aid is possible. Loans could be offered on attractive terms to help the modernisation and re-equipment of yards, and the revaluation of yards for rating needs to be examined because of its effects on costs. Pressure needs to be brought to bear (perhaps under the threat of legislation) to end certain union practices, which lead to demarcation and other disputes. The industry has made an immense contribution to the wealth of the country in the past. Given some help to overcome its present troubles we have no doubts that it can contribute more wealth to the nation in the future.

TWENTY-FIVE YEARS OF B.B.C. TELEVISION

This week has seen the twenty-fifth anniversary of the B.B.C. television service, which was officially opened for regular broadcasts on November 2, 1936. At first the Baird 240-line and the Marconi-E.M.I. 405-line systems were used in alternate weeks, but on February 5, 1937, the Postmaster-General announced that a single-set of standards would be adopted, namely 405 lines, 25 pictures per second, with interlaced scanning giving 50 frames per second; these were the standards of the Marconi-E.M.I. system, and have continued to the present time. Transmissions, then made from the Alexandra Palace, were suspended on September 1, 1939, on the eve of the second world war. They were resumed on June 6, 1946, the Alexandra Palace station continuing in operation until superseded by the Crystal Palace transmitters in 1956. Meanwhile five high-power stations had been opened in other parts of the country, and a programme of building further medium-power and low-power stations was in hand. The result of these developments so far has been to bring the B.B.C. television coverage of the population of the United Kingdom up to 98·8 per cent. Further extension, and improvements of service in areas where reception is difficult, are being provided by the current programme of satellite stations. These operate on the "translator" principle developed by B.B.C. engineers, in which signals received from a more powerful station are retransmitted on a different channel without demodulation. These twenty-five "satellites" will raise the coverage to 99·4 per cent.

It is not our purpose here to discuss B.B.C. television as a medium of entertainment and education. One of its achievements must be counted the making familiar to the public of what are known from without as "both sides of industry", and from within, individually, as "the other side". Neither appears particularly alarming or formidable when seen within the compass of a 21in screen, and the fact that B.B.C. interviewers are sometimes rebuked for being unkind to tycoons or trade union leaders suggests that the world at large is beginning to feel for each the kindly affection it normally reserves for polar bears or giant pandas. This may provide a better background for our children in their industrial relations than stories of Tolpuddle or Peterloo.

B.B.C. television is a large-scale user of internal telecommunications; the network of transmitting stations is served by an extensive permanent system of Post Office cable and radio links, together with short v.h.f. or s.h.f. links equipped and maintained by the corporation for connections between a convenient programme-receiving point and a rebroadcasting transmitter which is not conveniently sited for picking up its programmes by direct reception from another station. Experience of working on frequencies as high as 7Gc/s has been obtained with B.B.C. mobile links in outside broadcasts. A better known facility, of course, is the Eurovision link, the foundations of which go back to a B.B.C. outside broadcast from Calais in 1950 and to the corporation's work on radio links and systems conversion in conjunction with R.T.F. in France for the reception of programmes originating in Paris in 1952. The first major European exchange of programmes, involving eight countries, took place between June 6 and July 4, 1954. Reaching out further still, the B.B.C. developed a method of sending short news films across the Atlantic by the telephone cable and introduced it in 1959. There is close contact with industry, the fruits of which are seen in many ways, such as industrial television and the development of the 4½in image orthicon camera tube, which this year has won an award from the American National Academy of Arts and Sciences for the English Electric Valve Company Ltd. This tube, designed originally for the B.B.C., is now used for medical X-ray image amplification as well as having industrial possibilities. With industry, the B.B.C. awaits the decision on line standards and the future of colour television. It is continuing its studies of propagation in Bands IV and V, the use of which would be necessary with a 625-line system. Whatever the future holds, the corporation's technical record over the past twenty-five years suggests that the problems of an expanding service will be met with originality and resource.

TRAFFIC IN SOUTH WALES

It has long been obvious, even judging by British standards of traffic flow, that traffic conditions in South Wales are particularly bad. Exactly how bad has now become painfully clear with the completion of a report on what is claimed to be the largest traffic survey yet carried out in this country. The survey was done by Mr. C. P. Andren and Messrs. R. Travers Morgan and Partners, for the Industrial Association of Wales and Monmouthshire. The British Road Federation, however, has evidently played its part as well. The survey covers virtually the whole of South Wales, i.e. from the Severn to the Pembrokeshire coast, and from Breconshire to the Bristol Channel. A total mileage of trunk and class-1 roads was established, and classified according to widths. Hazards to driving on these roads were emunerated, and traffic capacities deduced by the Ministry of Transport method for rural roads. Then, at 115 selected points, traffic counts were taken, to establish the traffic flow, in "passenger car units" for a seven-day period in August. These results were compared with the 1954 traffic census figures to ascertain traffic growth. To estimate growth in the future, a survey of industrial developments planned or under construction in the area was undertaken, and the effect of these developments on traffic estimated, and added to the national average rate of increase of 5 per cent per annum, although there are good reasons to believe that this figure is unduly conservative for South Wales. Forecasts of future traffic patterns were thus deduced.

The resulting picture is that of a road network already seriously overloaded. Without dwelling on this aspect of the study, however, it has become quite clear that as the roads are now, things will become really intolerable within the next few years. Perhaps the most interesting aspect of the report concerns the consultant's recommendations for improving the South Wales road system to the standard necessary to carry the volumes of traffic envisaged up to about twenty years ahead. These proposals turn out to be practical and not unduly onerous financially, compared with the national requirements for expenditure on roads estimated at the I.C.E. Highway Needs Conference. In scope and presentation, the suggested programme brings to mind the "Road Plan for Lancashire" prepared some years ago. An initial expenditure of £86 million is recommended, spread over seven years at an average rate of about £12½ million; then, a sum of £34 million spent over the following thirteen years. The individual projects in this plan are integrated in a logical manner to give a comprehensive road pattern for the whole area, following the capacities dictated by the forecast for future traffic volumes. Since the whole area is so important industrially, and a high proportion

of the traffic will serve the various industries, it seems unlikely that, even with conditions as they are to-day in this country, a better case for road expenditure could be made out.

RESEARCH WITHIN INDUSTRY

In his Presidential Address to the Institution of Mechanical Engineers last week Sir Kenneth Hague discussed the co-ordination of research. As chairman of Babcock and Wilcox Ltd. he views research as a user of it. We suspect, indeed, that he has little time for the kind of research, appropriate at universities, which is inspired by sheer curiosity and is unrelated to any foreseeable use. In discussing the programme of a works research department, for example, he remarked "There is little doubt that frequently items are included in a programme of research because they entail the kind of work which certain research workers would themselves like to do, whereas careful consideration of the programme might show that there is important work which has not been included or not been given the necessary priority." He regarded the development of such a situation as a waste of trained scientific manpower (a point upon which it would be possible for a fundamentalist to dispute with him), a waste of financial resources (there the industrialist speaks!) and as not fulfilling the requirements for which the department was set up, which comes to the heart of the matter. Industrial research, more especially research within industry, should be directed research, directed to foreseen useful ends. Research workers with a compelling urge to do researches that particularly interest themselves are thus ill-placed in the laboratories of industrial firms. Much of what Sir Kenneth had to say related also, naturally enough for one occupying his position and having had his experience, to that end of the research spectrum which verges upon engineering development. He was quite candid, for example, about the need for secrecy, something which is anathema to the more fundamental research workers. "At the level of company research it is inevitable that any new invention, or ideas that appear to be new only to the thinker or research worker, will be developed secretly, so that it can be ascertained whether or not commercial advantage can be gained as a result of such development." Interestingly his valuation of patent rights as a protection was not high. "It is often preferable to develop a new idea and put it into practice without heralding it with a patent application which enables competitors and even customers to apply all their efforts to circumvent the patent instead of working on their own original ideas." To put it shortly, though research within a large organisation, even one of world-wide proportions, can be and should be fully co-ordinated there are limits to the extent of co-ordination there can be between competing firms within any industry. It follows, this seems to suggest, that when a research association laboratory, bound to publish its discoveries to its members, or a full D.S.I.R. laboratory, bound to publish to the world, has developed any device sufficiently far for its commercial possibilities to be discerned it is desirable that it should leave further advances to be made in secret by interested firms. Or is it? The subject is not one on which we would like to be dogmatic.

Sir Kenneth also discussed co-ordination of research between universities and industry. On that subject he pointed out "it must be borne in mind that the first responsibility of a university is educational, so that the facilities in buildings, equipment and manpower which can be set aside wholly for the purpose of industrial research are naturally limited." Nevertheless "in spite of many difficulties" he was convinced that better use could be made of the facilities available at universities. Lord Hailsham, in an Address last week to a Commemoration Day audience of Imperial College, of which extracts are printed elsewhere in this issue, also referred to the need to encourage more co-operation between universities and colleges on one side and industrial firms on the other. Sadly, however, neither he nor Sir Kenneth in their Addresses made any reference to design. In these post-war days when the necessity for more research has become more widely recognised, over-emphasis we suggest, has been laid upon its relative importance. Research has come to be spoken and written about as though it was an end in itself. That may be true of fundamental work in a university; it certainly is not true of engineering research! Engineering research is undertaken for a purpose and that purpose is to provide information by the use of which engineering designers can improve upon and cheapen existing products and design entirely new ones. Why have people ceased to extol design and given the palm instead to research? For, however fine its research department, no engineering firm can flourish if it fails to retain the services of talented designers capable of making good imaginative and creative use of research discoveries.

The Engineer—100 Years Ago (NOVEMBER 1, 1861)

Railway Brakes

Many were the accidents in the 19th century resulting from railway trains having inadequate brakes or, indeed, with the exception of the locomotive and one or two vehicles in the train, no brakes at all. Many were the efforts to devise an effective brake and our columns reflect the attention being given to the subject. The answer was not to be found for many years, but new forms of brake appeared from time to time. Such a brake was that invented by John Watkins, of Birmingham.

Watkins's brake consisted of a double-flanged drum mounted on each axle of a vehicle between the normal wheels, and a pair of "... iron straps or grips" which cause wooden brake blocks to "... clip the periphery of the brake wheel (or drum) when in action." A screw rod passed through tapped bosses at the top ends of the grips, and when turned, pulled the grips together, so applying the brake blocks to the drum. Power to apply the brakes came from a set of spur gears and a capstan wheel in the brake van, and the rods could be coupled between each pair of vehicles, so making the brake continuous throughout the train. As an alternative to manual power for screwing the brake on, the "... action may be applied by centrifugal power from the axle, a worm or pinion on the axle working in a spur-wheel gearing into a second wheel fixed on the longitudinal screwed shaft. These spur-wheels may be thrown in and out of gear by any suitable means, and at the will of an operator, so that the running speed of a train increases the power applied to the brakes."

There would have been technical problems in the operation of this brake, but its major faults lay in the fact that it could only have been applied from one point in the train or at least from a very limited number of points, and that if the train parted the brake, when its full power was most needed, would only have been operative in that portion of the train containing the brake van. These faults, of course, it shared with many other brakes both before and after it.

Army Weapons and Vehicles

By R. M. OGORKIEWICZ, M.Sc.(Eng.), A.M.I.Mech.E.

Last week the War Office held one of the biggest demonstrations of Army weapons and equipment for several years. The display included a number of interesting new items, such as the "Chieftain" battle tank seen above, and provided an opportunity for a more general survey of recent military developments.

BY comparison with the attention attracted by spectacular displays of military aircraft and the traditional interest in naval affairs, Army equipment tends to get far less notice. In consequence, not only has the Army lost some of the potential public interest and support but many people have gained the impression that little is happening in this field. Such a notion belies the facts, even though not as much has always been done as one would like to see, nor have some of the developments proceeded as rapidly as they should have done. This was clearly shown by the display of Army weapons and equipment held last week at the Fighting Vehicles Research and Development Establishment in Chertsey, Surrey. The display, organised by the Master General of Ordnance, included several new items of equipment and, in a general sense, not only helped to bring the Army into the limelight but also provided a timely opportunity for a re-examination of recent military developments.

So far as weapons are concerned, the display covered the whole range, from small arms to the "Blue Water" surface-to-surface missile designed for long-range artillery support. The smallest was the Canadian-made 9mm semi-automatic pistol. It is by no means new, having been developed by the late John Browning and introduced by the Belgian Fabrique Nationale in 1935. However, it represents a well-proved and widely used hand-gun whose adoption as a replacement for the 0·38in revolvers was long overdue. Among its virtues is the fact that it fires the Parabellum-type round which, since its introduction in 1902, has become the world's most widely used pistol ammunition. The same ammunition is also used with the 9mm L2A3, or Sterling, sub-machine gun which has now replaced the earlier 9mm Stens. It is interesting to note that in common with most others the British Army continues to have a requirement for a sub-machine gun firing pistol-type rounds whereas the Soviet and U.S. Armies no longer do so. Instead, both now rely on automatic rifles, such as the Avtomat Kalashnikov and the U.S. M14, whose British equivalent is the Belgian-designed 7·62mm semi-automatic FN rifle, or L1A1, which has now replaced the earlier bolt-action 0·303in No. 4 rifle.

In parallel with the adoption of the FN rifle, and with it of the 7·62mm N.A.T.O. round, the old-established Bren light machine gun has been modified to fire the same ammunition. The new version, known as the 7·62mm L4 machine gun, is now in service, but it only represents an interim solution pending the introduction of the 7·62mm general purpose machine gun. This Belgian-designed belt-fed weapon has been adopted only recently by the British Army, at the conclusion of protracted trials, but similar guns are already in use with the Swedish, as well as Belgian armies. It can be used either in the role of a light or medium machine gun and thus follows the trend set in the 'thirties by the German MG-34 belt-fed dual-purpose machine gun. Unlike the latter, but like the closely comparable M60 general purpose machine gun adopted a few years ago by the U.S. Army, it is gas operated. This mode of operation is now generally preferred to the alternative recoil-operated systems because gas operated machine guns are somewhat less critical with regard to their functioning and easier to develop. For use as a light machine gun it is provided with a bipod and shoulder stock but when used to deliver sustained fire it is mounted on a tripod and the butt is removed. The only other change which is necessary is the substitution of a heavy barrel, but a dial-type sight may also be added. Because of its versatility, the general purpose machine gun will replace not only the magazine-fed Brens, but also the heavy, water-cooled belt-fed Vickers, which are by far the oldest machine guns used by any major army and whose replacement becomes increasingly urgent.

Another urgent problem is the replacement of the 3·5in rocket launcher, which is at present the standard close-range anti-tank weapon. Trials have been carried out with two possible replacements, both of which were on show, but as yet no decision appears to have been taken. One is the Canadian 3·2in Heller rocket launcher; the other is the Swedish 84mm Carl Gustav recoilless gun. Both are shoulder controlled and

Fig. 1—7·62mm general purpose machine gun as used for sustained fire: note the heavy barrel

Fig. 2—Canadian 3·2in Heller anti-tank rocket launcher and practice rocket

have an effective range of about 350 yards, which is three times the range of the current 3·5in rocket launcher. However, the Heller's rocket is electrically ignited and its performance is more likely to be affected by ambient conditions whereas the Carl Gustav's round is fired mechanically, by percussion, and the Swedish weapon is more handy. Moreover, it is highly significant that the U.S. Army, which introduced the anti-tank rocket launcher in 1942 in the form of the 2·36in "Bazooka," and developed the

Fig. 3—Swedish 84mm Carl Gustav anti-tank recoilless gun

current 3·5in model, has now decided to replace it by the 90mm M67 recoilless gun. The Carl Gustav is very similar to this American gun but it is even lighter, for it weighs 28½ lb compared with 33 lb, and its adoption would give the British infantry an effective and badly needed medium anti-tank weapon.

The standard heavy anti-tank infantry weapon is the 120mm "Mobat" recoilless gun, which has an effective range of about 900 yards, and is now being supplemented by the 120mm "Wombat." The "Wombat" has been referred to already on these pages* and represents a further and considerably lighter development of the 120mm recoilless anti-tank gun series began in 1945. It is normally fired from the ground but it can also be fired from the ¾-ton Land Rover on which it is carried. The official view appears to be that the "Wombat" would only be fired from its truck in an emergency but the firing of recoilless guns from vehicles is already commonly practised by the U.S. Army and is to be commended as it enables these guns to change position quickly, thus minimising the effect of their conspicuous back-blast. Indeed, much might be said for providing the heavy recoilless guns with a special low-silhouette light armoured carrier from which they would normally be fired. This would not only reduce their vulnerability but it would also increase their overall effectiveness, and such vehicles are already being developed elsewhere.

No decision has yet been taken about the Vickers "Vigilant" anti-tank guided missile†, which is undergoing trials, but some such weapon is needed to provide the infantry with longer range anti-tank weapons. Several N.A.T.O. armies already use the French SS-10 and similar anti-tank guided missiles for this purpose, and it is time for a similar weapon to come into service in the British Army, whether is is the "Vigilant" or not. In the meantime, the possibility of extending the use of small anti-tank guided missiles was demonstrated by an experimental mounting of two "Vigilants" on the turret of the "Ferret" Scout Car Mark II, or F.V.701 E, which can carry two additional missiles stowed away. The provision of such missile-armed "Ferrets" would clearly increase the effectiveness of light armoured units. The "Ferret" itself, which is manufactured by the Daimler Company Ltd., has already proved a very successful vehicle and a considerable number has been exported, as well as being supplied to the British Army. Its one possible weakness is the fact that it is still not armed with anything more powerful than a 0·30in Browning machine gun, whereas other light armoured vehicles, which it is likely to meet, are armed with 12·7mm or 14·5mm heavy machine guns, at least. Thus, there appears to be a need for a new version, which could be armed with a 20mm high velocity cannon, quite apart from a missile-armed model.

Another wheeled armoured vehicle with guided missiles which was on show was the "Hornet." This is the standard launcher for the "Malkara" heavy anti-tank missile, two of which can be fitted to the launching arm and fired in fairly rapid succession, while two more can be carried, partly dismantled, in the vehicle. The vehicle itself is a derivative of the F.V.1609, the armoured version of the 4×4 1-ton truck produced by Humber Ltd. It weighs 5·7 tons and is, therefore, not only air-transportable but also parachutable. In consequence, the "Hornet" with

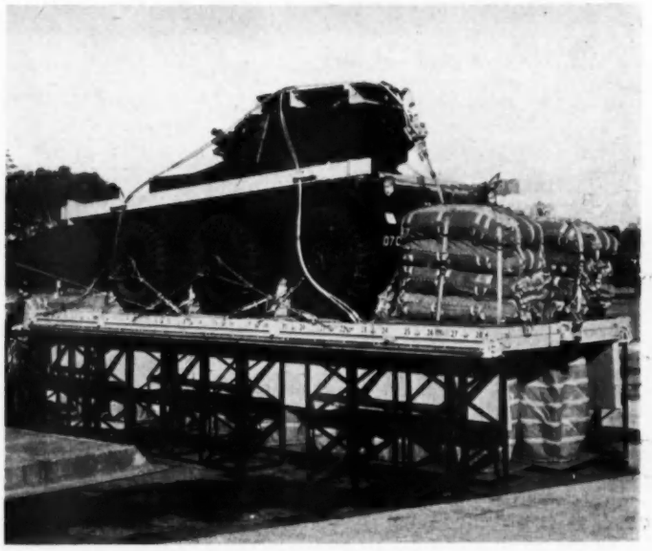
Fig. 6—The new 81mm mortar and bomb

the "Malkara" missiles represents a powerful mobile anti-tank system which can be used by airborne units, as well as others.

The technique of dropping even heavier wheeled armoured vehicles was demonstrated by a special platform with a "Saladin" armoured car. The heavily stressed platform for dropping equipment of up to 24,000 lb and its associated cluster of parachutes forms an interesting development, but the practical use of what was shown is questionable while transport aircraft remain in short supply. Even ordinary air transport of armoured vehicles of the "Saladin's" 23,520 lb weight seems doubtful for while the Short "Belfast," a wooden mock-up of which was shown, will be able to carry three, the number of such aircraft is going to be extremely limited and at best only a few vehicles could be delivered. In consequence, military commanders will, in all probability, prefer to use the available aircraft for other

* "Defence Research," THE ENGINEER, November 13, 1959, page 593.

† "Infantryman's Guided Weapon," THE ENGINEER, July 14, 1961, pages 63–65.



Figs. 4 and 5—(Left) "Hornet" missile launcher with two "Malkara" missiles fitted to the launching arm and a third missile, without its control surfaces, projecting from its stowage place. (Right) "Saladin" armoured car on the heavy platform developed for dropping equipment of up to 24,000 lb

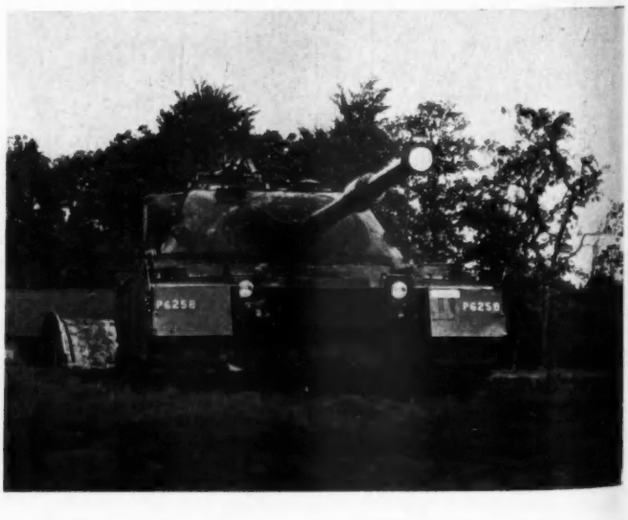
Fighting Vehicles

The "Centurion" Bridgelayer can span 45ft with its 52ft bridge without the crew of the vehicle having to expose themselves. This is one of several special purpose armoured vehicles based on the "Centurion" which have been developed to support tanks. Another, a "Centurion" Armoured Recovery Vehicle, can be seen RIGHT behind the Bridgelayer pulling a "Centurion" Mark 9 105mm gun battle tank out of the ditch. There is also a special Beach Armoured Recovery vehicle which can wade in 9ft 6in of water and is intended specially for use in amphibious landings.

LEFT, American-designed rolling-wheel liquid transporter which is being tested by the British as well as the United States armies. Each of the two cells holds 420 gallons, and can be towed across country either in single, two-cell units, as shown, or made up into trains of several units. One of its advantages is that it will float fully loaded with petrol or oil.

"Ferret" Scout Car Mark II with two "Vigilant" anti-tank guided missiles mounted on its turret and two carried stowed in their launching cases at the side of the vehicle BELOW LEFT. The missiles can be fired and guided on to their target from within the turret and the vehicle with its missiles represents a highly mobile anti-tank weapon system, which could represent a major threat to the most heavily armoured enemy tanks.

One of the outstanding features of the "Chieftain" main battle tank is its low silhouette, seen in the photograph BELOW which also shows the sloping armour of the turret and the fume extractor on the barrel of the new 120mm high velocity tank gun. In contrast to the new British light armoured vehicles, which have rubber-padded and rubber-bushed tracks, the "Chieftain" has a conventional all-steel track. Some features of the tank are deliberately obscured by temporary fitments.



Figs. 7 and 8—(Left) F.V.432 armoured personnel carrier showing the rear access door, attachments for buoyancy aids on the sides of the superstructure and rubber shrouds covering the top of the track. (Right) "Abbot" 105mm self-propelled gun, showing the inclined frame of the collapsible canvas hull

purposes. A corollary to this seems to be that if armoured vehicles are to have a chance of being used in airborne operations, as they should, then they need to be lighter than the "Saladin."

What can be done sometimes in reducing the weight of military equipment was demonstrated by the new 81mm mortar, which weighs 75 lb and is, therefore, about 50 lb lighter than the 3in mortar which it will replace. It is also lighter than the standard United States M29, which weighs 93 lb and provides a recent example of the 81mm mortar used by most armies. It is not, however, lighter than the experimental U.S. T227E2 which was also designed so that each of its three main components weighs about 25 lb, for ease of handling. The design of the new British mortar has involved the use of a light alloy base plate of Canadian design, a barrel of high strength steel thickened towards the base and grooved, and of a somewhat unusual bipod. Its maximum range of 4000m is greater than that of the present 3in mortar and comparable to that of the U.S. M29 mortar with the 9 lb M362 bomb, but its British equivalent is believed to be more lethal and accurate. A most interesting feature of the new 81mm mortar bomb is the use of a plastic obturating ring, which helps to reduce the leakage of gases between the bomb and barrel, but in addition to its British bombs the mortar can also fire any 81mm N.A.T.O. ammunition.

Another new and important item of infantry equipment was the F.V.432 armoured personnel carrier. The general layout of this tracked vehicle is similar to that established some years ago by the United States armoured infantry vehicles. Thus, it has a box-like superstructure with vertical side and rear plates and an engine compartment at the front, on the left, alongside the driver. In contrast to the recent American carriers, which have a large ramp at the rear, the F.V. 432 has a side hinged doors ; in addition, there is a large hatch in the roof of the crew compartment and separate hatches for the driver and commander, who operates an externally mounted 7·62mm general purpose machine gun. It can carry up to twelve men, including the driver, and like the U.S. M113, and the earlier M59, it is sealed for flotation and provided with a hinged trim vane at the front, but apparently requires the addition of buoyancy aids to have sufficient freeboard. In consequence, it has neither the ability to swim across inland waters without preparation, like the American and Soviet carriers, nor the advantages of low silhouette and well sloped armour, which the German carriers possess by foregoing the ability to float without additional gear. However, a reduction in weight could bring the flotation characteristics of the F.V.432 in line with the former, and in general it follows the American concept of armoured carriers as vehicles which carry infantry for dismounted action rather than that favoured, among others, by the German Army which considers that infantry should also be able to fight from within its vehicles.

Irrespective of all this, the F.V.432 represents a considerable advance on the two armoured carriers at present used by the infantry. The F.V.603 "Saracen" armoured personnel carrier is an excellent vehicle in many ways but being wheeled it has its limitations and is not too well suited to close co-operation with tanks. This applies even more to the F.V.1609, which suffers further from being an adaptation of a truck design. Being tracked, the F.V.432 is better suited to operating off the road, has a lower silhouette and being armoured all round it provides a high degree of protection against the immediate and residual effects of nuclear weapons, as well as small arms and shell fragments. In addition to its primary role of carrying a section of infantry, it can be adapted to the role of a command vehicle or ambulance, it can carry a 3in or 81mm mortar, which can be fired from it, and it can also carry a 120mm "Wombat," but this, unfortunately, must be dismounted before it can be fired.

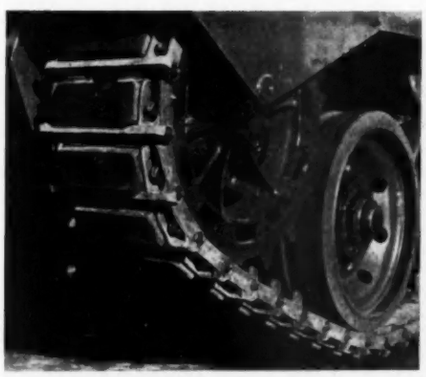


Fig. 9—Rubber-bushed and rubber-padded track of the "Abbot" self-propelled gun ; the pads are replaceable

The existing prototypes are powered by the Rolls-Royce B.81 petrol engines, but production vehicles are to be fitted with the corresponding "K"-series multi-fuel engines,‡ which are interchangeable with the B.81. Apart from the ability to run on a wide range of fuels, the installation of the multi-fuel engines should also bring about an increase in the operating range which is estimated at 40 per cent.

Suspension of the F.V.432 resembles that of the American M113 and embodies five double rubber-tyred road wheels on each side, the wheels being mounted on trailing arms and sprung by transversely located torsion bars. In addition, the front and rear wheel stations are provided with telescopic dampers. There are two return rollers per side and a close fitting rubber shroud over the top of the track, the function of the shroud being to improve the efficiency of the tracks as a means of propulsion in water.

The track itself is of even greater interest, as it has rubber bushed pins and rubber road pads. Rubber bushed and padded tracks have been used on American armoured vehicles since the early 'thirties but this is the first time that they have been adopted on a British vehicle and there still seems to be some reluctance to acknowledge their superiority. This may be due partly to a lack of familiarity with this form of track, but, judging by the extensive American experience, the arguments against it based on its greater cost and weight can be more than countered by its improved performance and life.

The advantages of the rubber bushed track arise from the fact that relative motion between pins and shoes takes place by shearing of the rubber and not by sliding between metal surfaces, as it does in the conventional dry-pin joint which is open to abrasive dirt. The rubber pads help to cushion shocks when driving on hard surfaces and to reduce the damage to roads. As on the lighter American vehicles, the rubber pads are removable and are attached to the track shoes by a single bolt, which is sometimes criticised because of the greater attention required in service by

‡ "Multi-Fuel Engines," THE ENGINEER, November 20, 1959 page 628.

comparison with track shoes with bonded pads. Another feature on which there is as yet no general agreement is the rubber padding of the back of the track, which is present on American vehicles but not on the F.V. 432. This improves tyre life but it also increases rolling resistance, as well as cost.

Whatever the details, it is to be hoped that the development of rubber bushed and padded tracks will now be pursued more vigorously. One of the obstacles to this has been the lack of manufacturing facilities in this country, but steps are finally being taken to remedy the situation and this should ensure a source of supply for British vehicles, as well as an opportunity to sell abroad where the demand for rubber bushed and padded tracks is growing.

The same type of rubber bushed and padded track is also used on the new 105mm " Abbot " self-propelled gun, whose chassis is essentially the same as that of the F.V.432. The general conception of the " Abbot " appears to follow that of the United States T195 105mm self-propelled howitzer, which appeared about two years ago ; like the T195, it has its gun mounted in a fully-enclosed turret with 360 deg. of traverse. It is also amphibious but while the more bulky aluminium alloy armoured American vehicle can enter water without preparation the British vehicle needs to erect a short canvas hull, which is normally carried collapsed, to secure sufficient buoyancy. In gun calibre the two are identical, but the " Abbot " with its 105mm 34 lb shells is not only an advance on the present 87·6mm twenty-five-pounder but is superior to the American 105mm howitzer because of its longer (10 mile) range. The " Abbot," which is manned by a crew of four, can fire in high elevation, like a howitzer, or in low elevation, when it can also engage tanks. Thus, it will provide the Royal Artillery with a versatile and highly effective self-propelled gun, which is all the more gratifying since it is the first properly designed British self-propelled gun since the pioneering efforts of the early 'twenties.

In contrast to self-propelled guns, the development of tanks has been continuous, and the appearance of its latest product was undoubtedly the most important feature of the whole demonstration. The new tank is the " Chieftain," which carries a high velocity 120mm gun and is probably the most powerfully-armed tank to appear to date—yet, it is lighter than the " Centurion " as it weighs about 47 tons. In consequence, it can replace both the 65-ton " Conqueror " 120mm-gun tank and the 50-ton " Centurion," whose current version is armed with a 105mm gun. Apart from its gun, which is both lighter and more effective than the " Conqueror's " 120mm gun, another major feature of the " Chieftain " is the adoption of a supine position for the driver, which makes it possible to reduce the height of the hull and hence of the whole vehicle. This is most desirable since it is more difficult to lay a gun in elevation than in traverse and, therefore, for a given area exposed the lower the tank the smaller the chance of being hit ; the prospect of its survival on the battlefield is further enhanced by the exceptionally well sloped armour, particularly on the turret front. One further feature of the " Chieftain " which calls for comment is its 700 b.h.p. L-60 multi-fuel engine developed by Leyland Motors Ltd.

At present the " Chieftain " exists only in prototype form but orders for production tooling were announced almost a year ago, so its delivery to the troops should be only a matter of time. However, its development has been a matter of some controversy, its gun being regarded in some quarters as larger than necessary and its weight, which is related to some extent to its gun as well as the thickness of armour, as excessive. A lighter, more mobile type of battle tank, weighing between 30 and 40 tons, has been advocated particularly strongly in Germany, but the recent German interest in the " Chieftain " may possibly lead to a change of policy there and in other N.A.T.O. countries. The United States, which have already followed the re-arming of " Centurions " with the 105mm gun by adopting the same gun for its current M60 battle tank, may also again follow the British example and adopt the new 120mm gun for its tanks. These possibilities provide a good augury for the " Chieftain " and if it lives up to expectation it should maintain the position of this country as a leading manufacturer of tanks, a position well established by the sale of some 2500 " Centurions " to other countries.

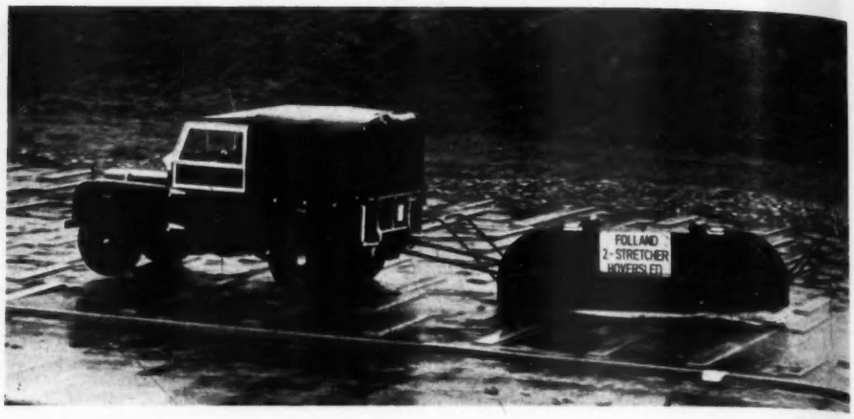


Fig. 11—" Hoversled " developed by Folland for carrying two seriously wounded men over rough ground being towed at speed by a Land-Rover

A relatively new avenue of advance is afforded by the ground effect machine, which has the advantage of being unaffected by the fine structure of the ground (which may even be water) but the disadvantage of being acutely sensitive to large scale irregularities, i.e. it can be contained by banks or trees and cannot traverse significant gradients. While ground effect machines with wheels for traction and guidance have been proposed, a reasonable and attractive exploitation of the principle was displayed in the shape of a trailer embodying the Cockerell " Hovercraft " principles ; our illustration shows two stretchers being carried on the vehicle at a speed that is causing the towing vehicle to bounce badly. This form of train is clearly of interest also for heavy loads where the carrying capacity of tyres dictates the design, but in such a case the air consumption will be high and not economically to be provided either by the tractor's pneumatic system directly or, as on the example demonstrated, self-contained engine-compressor plant. There was demonstrated also a cushion-craft to carry one stretcher and be moved by one man.

All told, the demonstration showed that the Army is making progress towards providing itself with modern weapons and equipment comparable with those used by any other army. In some cases, as with the 81mm mortar and the 105mm " Abbot " self-propelled gun, it has not only caught up with the general trend but has produced weapons which in some respects surpass others of similar size. In a few other cases, such as the main battle tank and the high velocity tank guns with armour-piercing discarding sabot ammunition, it appears to lead. The problems which remain are to produce the various new models quickly enough, so that they enter service in numbers without much further delay, and to develop still better weapons and equipment.

Fig. 10—" Chieftain " battle tank with 120mm gun

Functions of Universities

Thursday of last week was Commemoration Day at Imperial College, South Kensington, London. At an academic ceremony held in the Albert Hall, Lord Hailsham, Minister for Science, was a special visitor. We print below, almost in full, his address.

THE eternal struggle of humanity is to reconcile freedom with authority, individual self-expression with the requirements of society. There have been many definitions of freedom, ranging from national independence to freedom of worship, from universal suffrage to full employment, from social security to private enterprise. As a lawyer, as a politician, as a moralist, I have discussed them all, and admit that all have a certain contingent value. As a philosopher I have found them all inadequate. None of them by themselves is intellectually satisfying.

I suspect that one reason for this is that, whatever it means, freedom cannot be seen in isolation from the search for the just and the true, the beautiful and the good—the ultimate values which men place upon their existence on the planet. In their origins in the ancient world, the universities were the places where this search was correlated and discussed. And the academic freedom of the universities themselves, their intellectual stature, their moral quality, seem to me to be matters of immense importance, theoretical not less than practical, in the discussion of the relative values of tyranny and freedom, of democracy and authority, of law and morality. But if this is so, it is at least surprising that this is a matter which is almost never mentioned by the theorists and lawyers who indulge in most of the arguments.

But if a unity of purpose, an integrated understanding of man and his environment, is not to be found in the universities, it will not be found in the nation, or in the world. This is dimly apprehended even by the multitude, even by the popular press when they pay sometimes disproportionate attention to the strange actions of undergraduates —or to the even stranger opinions of Professors. But in terms it is almost never said. Yet the university world is the true melting-pot of society, the one great mixer where class distinctions are abolished before our eyes, the one aristocracy of merit divorced from privilege, the one democracy where equality of opportunity is not confused with equality of achievement, reward, or esteem. In the humanities it is generally accepted that, at this level, teaching and research cannot be separated. My thesis to-day is that teaching and research in science must similarly be allied.

Vocational Training

Yet side by side with their function as the teachers of human society as a whole, the universities have also the task of providing vocational training. It is idle to disregard or minimise this aspect of their activities—although many academics are far too fastidious to speak of it openly, and sometimes write letters to the papers decrying its discussion. The plain truth is that if it had not been for this function, the universities would have neither been brought into being nor survived. If the Church had not needed educated priests, if the State had not needed educated administrators, if industry had not needed educated executives and technologists, there would have been no universities ; and although medicine and law and the engineering professions, at least in this country, have contrived partly independent systems, I doubt whether even these would survive—or maintain adequate standards—without a parallel system of academic courses to give them intellectual body.

But the truth is that the two functions are not independent of one another. Even on the vocational plane, teaching of the order we require for our administrative, our scientific and industrial leaders cannot be wholly divorced from research—the true pioneering of knowledge of all kinds. Research will tend to become barren and researchers to die out, if attempts are made to divorce it from teaching. But how is research to be financed? Who is to call the tune? And if the tune is to be called by the spirit of research itself, what conceivable motive will be his who pays the piper?

Academic Freedom and Finance

The issue of academic freedom has never been very far below the surface of political life. At the time of the Reformation, and the Civil War the questions were only too obvious. But in recent years, and certainly until 1939, they were scarcely asked. No one grudged the Prime Minister the right to nominate a few Regius Professors ; and academic resources depended as much on fees, endowments, and donations as upon public funds. But by 1946 it was apparent that the scale of expansion forced upon the universities by the range and rapid development of modern knowledge, and the insatiable appetite of industrial society for trained graduates, made it necessary that from henceforth the main patron of the universities would be the State. Happily to hand was the appointed instrument of State and university—the University Grants Committee, brought into being in 1919. I would think that on the whole this has managed to the general satisfaction to administer public generosity without corrupting academic freedom.

In one direction, however, the U.G.C. has required supplementation. Built into university life is an innate conservatism—no bad quality, this, for any institution but one that needs to be balanced by spirit of initiative and innovation. From their start, the Research Councils—by which I mean the Department of Scientific and Industrial Research, the Medical Research Council, the Agricultural Research Council, and the Nature Conservancy—have encouraged the initiation of new projects of research, and particularly in relation to medical research have founded whole teams of researchers within, but not necessarily as integral parts of, the universities. And in the last four years the total value of the research grants given to universities each year by the largest of these patrons—the Department of Scientific and Industrial Research—has increased threefold. I am rather proud that this has happened entirely within my own periods of office, since I regard the development as wholly to the good.

For a second function of the universities—to initiate new studies, to fill in gaps in the old studies needs (as no one knew better than your founder) a living patron, something more adventurous, and perhaps a little more selective, than in the nature of things the U.G.C. can be expected to be. The present size of the Government-sponsored research in the universities is, however, such as to give rise to new questions—both for the Research Councils and, I would say, also for the universities—which it will be my business and that of my successors in office to investigate in the coming months and years.

Speaking broadly it will be necessary to keep in mind the respective functions of the U.G.C. and the Research Councils. But, at this stage in my lecture, I would only mention, in passing, two small points. First, the permanent structure of the universities is clearly a matter for the universities themselves, and the University Grants Committee is the constitutional channel for Government funds. It is vital to remember that the Research Councils' function is not to finance science in the universities as a whole, but to provide funds for new developments in research which cannot be adequately dealt with within the framework of the quinquennial system. But at what stage, and by what mechanism, can work originally fostered by the Research Councils be handed over—and how is the handover to be reconciled with the academic law of the Medes and Persians against ear-marked grants?

Secondly, a similar question, though not entirely limited to research, arises in relation to laboratory technicians and assistants—whose activities form an indispensable part of virtually all scientific work in universities. It is not my function, or that of the Research Councils, to provide part of the permanent staff of universities. The U.G.C. rightly adheres to its policy of refusing ear-marked grants. This is a minor problem and can be solved within the University framework.

Expensive Research Tools

I pass back from these relatively small matters to my main theme. Since I first assumed Ministerial responsibility for the Research Councils, university research has been affected by a number of changes—both in scale and in character—in the field of scientific research generally. For one thing, in an increasingly wide range of disciplines the tools of research have become machines —and machines each of which is a major engineering project constituting a significant item in the capital investment programme.

Apart from the big machines, the accelerators, the radio telescopes, the gas bubble chambers, there is the problem of the new institutions, sometimes clustering round the facilities of a parent body, like N.I.R.N.S. round Harwell, yet half resenting and half resented by the parent organisation.

Closely related to the machines, but potentially larger still, are newly emerging fields of study, too big, almost from the first for association with individual teaching universities ; too big, almost from the first for purely national budgets ; often, like space research or the " Mohole " requiring immense vehicles and immense organisation for their initiation ; sometimes like " Cern " at Geneva, or " Dragon " at Winfrith Heath, involving international funds and wide implications in the field of foreign policy. Already a large number of international organisations, some bilateral, some regional, occasionally world-wide, some for research, others involving development, have sprung into being and require careful finance and clear thinking if they are to develop on right lines. Clearly all these changes raise important implications for the

relationship of universities to research, of universities to Government, and of universities to research, of universities to Government, and of universities to one another.

One such implication that is gradually becoming clear is that in certain branches of science it is impossible for every university to have equal treatment from the Government in all spheres. Ten linear accelerators each costing £1,000,000 will not make up for the absence of one linear accelerator costing £10,000,000—if one is needed ; and it is quite clear that not every university can hope to have a £10,000,000 accelerator. In this country, at any rate for the time being, there can only be one Jodrell Bank, one " Nimrod " ; there can only be a few gas bubble chambers; and only a few research reactors. Where are these to be placed? Who is to run them? Who is to arrange their research programmes?

And, when a number of such various projects are proposed by scientific enthusiasts, how are we to judge which to accept—particularly where these belong to different fields ? How are we to correlate the work of N.I.R.N.S. with the applications to D.S.I.R. in the field of nuclear and high energy physics—or with the budget of CERN in which we have only a minority vote ? How are the differing projects for radio-astronomy to rank between one another or with the applications for big machines in other fields ? How is either to rank with space research—another subject in which other countries are involved ? Can individual universities form partnerships or consortia ? Or should they all be provided for through a national extramural institution like N.I.R.N.S.? If the latter, where is the facility to be placed—inconveniently for all universities, or conveniently for only one or two ? If a facility is given to one university should any—and if so what—conditions be exacted for the benefit of the others ? If a facility depends on a particular man, what happens if he expires or resigns to move elsewhere ?

All these questions have actually arisen in a concrete form since I took office. Some I have had to decide. Some have been decided, with my approval, by the Research Councils. We are getting a certain amount of case-law and empirical wisdom about all this. But have we got the theory right ? This is something we shall have to discuss.

Diversification

But it is not only a question of big expensive machines that can be located in or near only some of the universities. Somewhat similar problems arise out of the increasing diversification of subject-matter. How far is it necessary or desirable, for example, to preserve the existing situation in which the scope for postgraduate work by students of a given institution is often limited by the extent of the facilities—either natural or artificial—which that institution happens by tradition or by accident to have in its possession or in its close neighbourhood ? Clearly, university statutes were—or should be—made for the needs of learning ; and not the needs of learning for the requirements of university statutes. Should university research still be limited in range by the migratory habits of mediaeval monks ? Should the availability of freshwater biology as a subject for research in Cambridge or Leeds be dependent on the contents of the Cam—or of the local Yorkshire factory effluent ? Should the availability of the Ph.D. to the staff of a Government Research Station depend on the place where each received his first degree ?

All these questions need public discussion. Government may have views ; but in many cases it will be the Vice Chancellors, the Courts and Senates, the faculties and the colleges, who supply the answers.

Universities and Industry

I come now to a different and even wider issue. What is to be the relationship between courses of study and research in the universities and the known requirements of industry ? Distinguished academics often write to *The Times* expressing disquiet at the tendency of industry to demand courses from universities in fields which are remote from traditional fields and are of deliberate relevance to practical life—for example, management studies. Similar questions are asked in relation to industrial research and in some of the applied social sciences. Is industrial money corrupting, as the author of one letter appeared to think ? If so, ought we not to think the same of Government money ? With due respect to the University Grants Committee, and to the Research Councils, Government is not fundamentally so disinterested as it pretends. Nor perhaps are even academics quite so pure. Nearly three-quarters of Government money going into scientific research goes on the defence budget. More of this than many people think is spent in the universities—and none of it could be spent at all without researchers such as those whom you are training here.

My own view, for what it is worth, is that in this country you should welcome and encourage industrial money, if only as a desirable and necessary counter-balance to Government money. At least it is not motivated by war or the fear of it. When I am asked, as I sometimes am, whether it is not degrading that people should be asking for private donations towards cancer research, because the Government ought to bear the cost, I reply that I would not sleep easy in my bed if I thought that either I or even the Medical Research Council were the only source of wisdom to decide what men and what ideas were worthy of support. The Americans may go a great deal too far academically in their dependence on private munificence ; educationally they suffer enormously from the fact that their schools and universities are in no sense a federal Government concern. But I think we may go too far the other way. From my point of view the degree courses available in British universities are too narrow in scope, and some of them are orientated too academically. I believe the same to be true to some extent of research work.

Academics and Industrialists

There is another important aspect to this. One of the most important subjects with which I am called upon to deal is the relative failure of British industry to make use of science and the scientist. I will not bore you with figures ; they are easily available. But, so far as I am concerned, the broad truth is that, outside a few main industries, far too few scientists are employed, and if more were employed some directors might not—in their present frame of mind—know what use to make of them. Not unnaturally, Members of Parliament and others ask me what can be done to improve the situation. Whatever the immediate answer, I am quite certain that the only radical cure lies in the universities, in a closer contact with industry, both education-wise and research-wise. Contact between intelligent and right-minded people is not corrupting ; almost invariably, it is stimulating ; and in my view at any rate academics have almost as much to learn from contact with industry as industry has to learn from the academics. Certainly, contact is the only way in which either will learn anything from one another. There is a great contrast between the extent of mutual regard and contact between academics and industrialists in Germany, which I have recently visited, and this country. In my view, neither gain here by the degree of apartheid they practice. And, incidentally, if that apartheid were broken down, both in teaching and research, my own opinion is that the human sciences, which are excessively neglected in this country, would also come into their own—both in the field of post-graduate research and in the field of new schools and faculties.

I realise that in addressing these remarks to you here in Imperial College I am rather preaching to the converted. Your Annual Reports provide plenty of evidence of strong ties with industry, and of wise generosity by industry in financing work here on a variety of research projects ; and there are also such things as the vacation training schemes by which students can gain valuable industrial experience. But is this enough? Certainly in Germany you get co-operation between universities and industry to a much greater extent. To take only two examples : you have in Germany far fewer obstacles than exist here to the combining of teaching with management or research in industry ; and indeed you get industrial concerns operating research institutes inside technological universities. I know, of course, that much can be said in support of our own British attitude, our ideological division between teaching and production ; but need we take it quite as far as we do? When we see the close contact, amounting almost to organic unity, which exists between industry and universities on the Continent, and when we see some of the results in terms of design, production, and sales on the one hand, and vigorous high-grade academic development on the other, we must surely ask ourselves whether the system adopted on the Continent does not possess competitive advantages.

There can be no easy or single way of doing this. But one important need is the creation of the kind of climate of opinion in which industry and the universities turn towards each other quite naturally, and cross the gulf which has too often divided them hitherto. And this is where you in this College come in—both those who are teaching, those who are being taught and those who are carrying out research. Every one who at some stage or other in his career goes into industry—whether in industrial research or in production or general mangement, and everyone of you who goes into Government scientific establishments or public administration, will not only be helping himself to bridge the gulf ; he will also be able to spread among others the habit and the desire of making and maintaining the closest contacts with university teaching and university research.

If the general rule must be that research and university teaching cannot be divorced, the wider development of the subject implies inevitably closer contact between universities, and Government research installations of one sort and another, between these and industry, between industries and universities, between universities and one another, between universities and places of research outside the general pattern which cannot conveniently be placed inside teaching institutions, between the scientific body within one nation and others of the same group—even between scientists of opposing groups of nations. These are not really rival conceptions for the organisation of research ; their roles are complementary rather than exclusive, and they are in truth part of a single complex of a constantly developing conception of a scientific life generally.

But, at the end of the day, if I am pressed with the familiar question of the egg and the chicken, if I am asked to define the point at which new growth is to be inserted into the scientific life of which I speak, I look, on the one side, to the universities to provide the new ideas ; but I accept the responsibility of Government to supply the initiative and the drive to convert these new ideas into actuality.

Obituary

DR. B. L. GOODLET, O.B.E., M.A., Sc.D.

WE regret to record the death on October 27, after a long illness, of Dr. Brian Laidlaw Goodlet, vice-chairman of the Brush Electrical Engineering Company Ltd. He was a brilliant and versatile engineer who distinguished himself in many fields, including high-voltage engineering and nuclear power.

He was born in Russia in 1903 and attended the Imperial School, St. Petersburg, before coming to England at the age of sixteen, after the Russian revolution. He started work as a fitter-apprentice at Vickers Ltd., Sheffield, and continued his studies at evening classes in Sheffield University. In 1923 he joined the Metropolitan Vickers Electrical Company as a special trainee and technical assistant and seven years later he was made head of the company's high-voltage research laboratory. There he designed and built a 1,000,000V impulse test equipment and his work brought him into contact with Sir John Cockcroft and Lord Rutherford who sponsored his admission to Cambridge University as an affiliated student in 1930. After graduating in 1932 he returned to Metropolitan-Vickers. In 1936 he was appointed to the Chair of Electrical Engineering in the University of Capetown.

On the outbreak of war in 1939 Goodlet joined the South African navy and, with the rank of Commander, became responsible for such technical matters as anti-submarine port defences, the degaussing of ships and bomb disposal. In 1943 he was seconded to the Admiralty as chief scientist of the Underwater Explosion Research Station at Rosyth. In 1944 he became scientific adviser to the Commander-in-Chief, Eastern Fleet, and a year later he was appointed engineering adviser to the Scientific Research and Experimental Department of the Admiralty, being awarded the O.B.E. for his services.

After the war Dr. Goodlet returned to Capetown University as Dean of the Faculty of Engineering. In 1950 he came to England as deputy-chief-engineer of the Atomic Energy Research Establishment at Harwell, where his main responsibility was the development of nuclear reactors for generating electrical power. Having studied various reactor systems he concentrated on the gas-cooled graphite-moderated natural uranium reactor and worked with R. V. Moore's team on the "Pippa" project and on the Calder Hall reactors which resulted from it.

Dr. Goodlet won many awards for his published papers : the Kelvin and Overseas premium of the Institution of Electrical Engineers, the Trevithick premium of the Institution of Civil Engineers, and the Thomas Hawksley Gold Medal of the Institution of Mechanical Engineers.

In 1956 Dr. Goodlet left the A.E.R.E., Harwell, to become chief engineer and director of the Brush Electrical Engineering Company Ltd. The following year he was appointed managing director, but in July last continued ill health forced him to resign and he was appointed vice-chairman.

Letter to the Editor

"CRITICAL LOOK AT THE NOVIKOV GEAR"

SIR;—In commenting on Mr. Walker's article "Critical Look at the Novikov Gear" on page 818 of your May 13, 1960 issue, I inadvertently gave the date of the Novikov patent as 1936, instead of 1956. This was not a printer's error ; the fault was entirely mine ; I was concentrating on that thirty-year gap between theory and practice and wrote down 1936 when I should have written 1956. I should be glad if you would publish this correction ; any gear engineer or patents man who may have my original letter on the file is advised to make the alteration now. For the record, the actual details of the Russian patent are : No. 109,113, Class 47h6, Application No. 550,525, April 19, 1956, to the Committee on Inventions and Discoveries of the Soviet of Ministers of the U.S.S.R.

A. M. GUNNER

Rugby,
October 13, 1961.

Books just published

Examples in Mechanical Engineering Science
212 *pages. Diagrams.*
Publisher : English Universities Press Ltd.
by H. McQUEEN, B.Sc.(Eng.), A.M.I.Mech.E.
Price 8*s.* 6*d.*

This soft-cover book is intended to serve as a companion volume to textbooks on heat and mechanics used by students for National Certificate courses. It consists of examination questions with fully worked answers and explanations of the more important features of the problem. The author is the Head of the Department of Mechanical Engineering, L.C.C. S.E. London Technical College.

[Reply Card No. 1267]

The Slide Rule for Students of Science and Engineering
116 *pages. Diagrams. 2nd ed. rev.*
Publisher : English Universities Press Ltd.
by T. G. C. WARD, E.R.D., M.A., and G. W. BLAKEY, B.A.
Price 7*s.* 6*d.*

This is a revised edition of a book first published in 1955. It includes an entire new section on the theory of slide rules. The authors are lecturers at the Royal Military Academy, Sandhurst, and the book was written with the needs of the technical branches of the Army in mind. It is intended as a course of practical instruction in the best methods of using a slide rule.

[Reply Card No. 1265]

Nuclear Power To-day and Tomorrow
270 *pages. Illustrations. Diagrams.*
Publisher : Methuen and Co. Ltd.
by KENNETH JAY
Price 25*s.*

This book is intended to give the layman a better understanding of the nature of nuclear power and an explanation of some of the major problems which have had to be overcome in making use of it. It is concerned primarily with nuclear reactors of different types, and economic as well as technical basic principles are explained in simple language. The author is a Principal Scientific Officer with the U.K.A.E.A. and details are given of British nuclear power reactors. There is an index, a glossary of technical terms, and a bibliography.

[Reply Card No. 1280]

Electrical Engineering Materials
208 *pages. Diagrams.*
Publisher : Prentice-Hall International Inc.
by ADRIANUS J. DEKKER
Price 42*s.*

This is the English edition of a book first published in America in 1959. The author is a Professor in the Department of Electrical Engineering, Institute of Technology, University of Minnesota and the book is intended for use in the fourth year of the Department's five-year undergraduate course. No attempt has been made to discuss quantum mechanical concepts, and the book is arranged so that the dielectric, magnetic and conductive properties of metals can be considered separately. There is an index, a brief bibliography, and answers for the problems appended to each chapter.

[Reply Card No. 1263]

Air-cooled Motor Engines
465 *pages. Illustrations. Diagrams.*
Publishers : Cleaver-Hume Press Ltd. and SNTL, Publishers of Technical Literature, Prague
by JULIUS MACKERLE, M.E. English Translation by K. Caslavsky and H. Snabl. Edited by E. H. Maclachlan.
Price 55*s.*

The author is head of the engine department at the Research Institute for Motor Vehicles in Prague and was formerly head of the design department at the Tatra works. The first part of his book deals with the fundamentals of heat transfer and general principles behind the design of air-cooled engines. The second part goes into design details of individual parts of the engine, especially where they differ from liquid-cooled engines. There is a survey, with diagrams and illustrations, of engines produced by manufacturers from many countries. There is an extensive bibliography and an index.

[Reply Card No. 1282]

Technical Glasses
465 *pages. Illustrations. Diagrams.*
Publishers : Sir Isaac Pitman and Sons Ltd., and SNTL, Publishers of Technical Literature, Prague.
by M. B. VOLF, D.Sc. English translation by S. E. Myhre and K. Fink.
Price 42*s.*

Dr. Volf is Chief Technologist of the Technical Glass Association at Sazava, Czechoslovakia, and has worked in practically all the fields of technical glasses discussed in the book. The subject is treated primarily from the chemical angle and the relationship traced between the composition of glasses and their properties. Over 850 different types of glass are discussed, the characteristics of various groups are presented and the glasses produced in different countries are compared. There are wide-ranging bibliographies to each chapter and various tables and indexes.

[Reply Card No. 1284]

An Introduction to Magneto-Fluid Mechanics
181 *pages. Diagrams.*
Publisher : Oxford University Press.
by V. C. A. FERRARO and C. PLUMPTON.
Price 25*s.*

The authors are respectively Professor and Lecturer in Mathematics at Queen Mary College, London, and the book is intended to provide an introduction to magneto-fluid mechanics for the use of physicists and engineers. The emphasis is on basic principles and the more general results. There are two sections on magneto-hydrodynamics and plasma physics : the former deals with the interaction of a highly conducting fluid with a magnetic fluid, and the latter treats in an elementary way with the kinetic theory of a highly ionised gas and includes discussions of transport coefficients, the conduction of electricity in a plasma in the presence of a magnetic field and plasma oscillations. There is an index and an extensive, classified, annotated bibliography.

[Reply Card No. 1285.]

MAINLY METALLURGY

by T. Henry Turner, M.I.Mech.E. M.I.Loco.E. A.R.Ae.S. F.I.M.

Long Welded Rails

THREE papers in the current issue of the *Journal of the Permanent Way Institution* throw fresh light on the fundamental changes that are now being made in railway track, although the composition of rail steels remain much the same. Thirty years ago there were no long welded lengths of rail in any of the main lines in this country.

Early in 1949 H. C. Trissler read a paper on long welded rails handling and maintenance on London Transport, and on pages 106–118 of Volume 79, Part 11, 1961, of the *Journal* of the P.W.I. he now returns to the same subject. During the past decade seven papers have been given on long welded rails and allied matters by members of the P.W.I. from various regions, and from these Trissler concludes that :

(*a*) Long welded rails have come to stay.

(*b*) Half mile lengths with adjustment switches are becoming generally accepted, although there is a good deal of evidence that this length will be increased with the possibility of adjustment switches eventually being discarded except where special conditions exist. There is also :

(*c*) The need for close attention to rail temperatures when finally keying or fastening, and

(*d*) The need for full ballasting and close attention to alignment, fastenings, cross levels and packing.

About a third of the track maintained by London Transport now has long welded rail ; during the past fifteen years over 26,000 running rail welded joints have been installed, representing approximately 150 miles of long welded rail, and the use of such rails continues to expand on this system. Their records show that track quality standards attained on long welded rail track, with the same input of labour, are consistently higher. The travelling public benefit by better riding and less noise especially in the tube tunnels.

A paper in the same *Journal*, pages 94–106, on " Long Rails and Modern 'Thermit' Welding ", gives a business-like description of the historical development of the "Thermit" rail welding and of the construction of long rails. Appropriately the author, Dr. Ing. Wilhelm Ahlart, comes from Essen where about 1900 Professor Hans Goldschmidt developed the now well known aluminothermic method of welding, and the Essen tramways pioneered its use for joining paved-in tramway rails. That procedure had become standard practice throughout the world by about 1910.

Main line railways had to approach the question of rail welding with greater caution because their rails were exposed above ground to expansion in the heat of the sun and contraction during frosts : they had already experienced buckling of rails in hot weather, even when expansion joints had been provided. "Thermit" welding of main line rails was first tried by the Hungarian State Railways (1904) and Mecklenburg (1910) and since 1924 the Deutsche Reichsbahn welded their rails in tunnels and on bridges with "Thermit". In 1928 they introduced the "Thermit" welding process to lengthen their 15 metre rails to 30 metres, and about 1932 they welded two single tracks to a continuous length of 1 kilometre each by "Thermit".

It was about that time that the then novel all-electric flash butt welding of rails was brought to a high state of perfection. Other processes employing gas welding or electric arc welding have also been used for this purpose in various countries. In 1959 the German Federal Railways welded about 20,000 joints by electric arc welding. That is, however, a relatively small number in comparison with their 433,000 rail weldings in 1958 and about the same number in 1959.

Since 1949 the German Federal Railways have continuously welded about 20,000 kilometres of tracks, mostly 90m or 120m long rail lengths transported to the site on the track and there joined by " Thermit " welding. To-day about 30 per cent of their main tracks and of all switches are continuously welded.

For the past two years many of the world's railways have used the new Quick Welding Process for which Thermit Welding, Great Britain Ltd., Rainham, hold the licence—this is a combined company of Goldschmidt-Electrotherm and Murex.

The third paper to mention rail welding in the same issue of the *Journal*, pages 86–93, was by the President, A. K. Terris, B.Sc., M.I.C.E., and it was entitled "Permanent Way : Its Recent History and Future Prospects". Dealing with the emergence of modern track he pointed out that 60 per cent of the length gang's time is spent in work associated with rail joints, and most rail failures occur at the joints.

On the Continent, in America and Australia great progress had been made towards the elimination of rail joints by electric flash butt welding in depots and joining the long lengths at the site by other techniques into continuous lengths many miles long. Great benefits were found to accrue. The L.T.E. and Southern Railway had welded bull head rails for tunnel and surface lines, and they had welded conductor rails. British Railways therefore decided to establish flash-butt rail welding plants on all regions and to proceed as rapidly as possible with the installation of continuous-welded rails.

The start was tentative. A draft Code of Practice was produced for all-regional use in 1957 but the progress was slow : greater delays than anticipated were experienced in getting the new plants into production. They are now, however, all working and the total of continuous-welded rail laid on British Railways already exceeds 340 miles. There is now more than 50 miles of continuous-welded track on the East Coast main line, practically the whole of which will consist of long welded track in ten years time.

Relative to the corresponding figures for the railways in France and Germany these figures appear small but by now much of the essential " know-how " has been acquired, and in August last year the Eastern Region of British Railways embodied its experience in a second code. Based on its own experience the Eastern Region laid down the following fundamental requirements where continuous-welded rails were to be laid in :—

(1) Bed of clean ballast 12in deep below sleeper (9in minimum,) preferably produced by ballast cleaner. (The ballast profile is described and dimensioned.)

(2) Twenty-eight hardwood (Jarrah) or twenty-four concrete sleepers per 60ft of rail length.

(3) Fastenings to be approved spring clips.

(4) Temperature at time of fastening rails down to be within the range 65–75 deg. Fah.

(5) No maintenance to be done on continuous-welded rail lengths above 85 deg. Fah.

The " Quick Thermit " method is now standardised for site welding and over 17,000 "Thermit" welds have been made on the Eastern Region in the past four years.

It was at one time thought that, for destressing purposes, an expansion joint should be provided every half mile. The use of rail warmers has rendered this provision unnecessary, and on the Eastern Region there are already lengths of 6000 yards only interrupted by insulation joints.

Other items in the evolution of the new kind of main line track to fit modernisation requirements were a particular form of baseplate and clip, concrete or Jarrah sleepers, and an elastic pad with characteristics related to those of the spring clip. The track thus became a resilient structure thereby relieving the baseplate/sleeper fastenings of the effects of vibration. Rocking of the sleepers was minimised. The tendency of the rails to move longitudinally through the baseplate was very greatly reduced. Henceforth it could be said that the resistance of the rail/sleeper assembly to longitudinal movement was greater than the resistance provided by the sleepers in the ballast.

During a recent run on long lengths of welded rails in Belgium the writer noted roaring due to corrugation of the rail top surface. The risk of corrugation in the new long lengths of rail, over the expected longer service in the track, will be greatest if all wheels are of the same diameter and nose hung motors are used without sprung wheel centres. The mechanical engineer can help to prevent this corrugation, which will spoil the perfection of long welded rails, if his designs contain more than one predominant wheel diameter. Civil engineers may slow down the damage to rails by corrugation if they find an easily applied and reapplied anti-corrosive treatment for the running surface. Between the elevated points of tyre and rail contact the rail head is eaten away by corrosion. The retardation of that corrosion, perhaps by phosphate solutions or rubbed-on zinc, will become more and more necessary as the fine new long lengths, of continuous rail, age in the expected long service. Research is now needed in this

direction in order to minimise the spoiling of the long rails by corrugation that will be unpleasant for passengers and cause harmful vibration to the stock.

In the sixty years since Professor Goldschmidt first thought of a practical means of rail welding in the track his ideas have inspired many metallurgical developments. Now their utilisation by engineers increasingly benefits the users of railways. "Long welded rails have come to stay."

Post-Graduate Training in Corrosion Science

The degree of Master of Science in Corrosion Science, may now be worked for in the University of Manchester Faculty of Technology. This is good news to engineers in the petroleum, chemical and process industries, and indeed to all others because none of our products and mechanisms are immune from destruction by uncontrolled corrosion. This news will be especially welcomed by the, nearly 600, members of the Corrosion Group of the Society of Chemical Industry, which was formed a little over a decade ago. In order to encourage the teaching of corrosion prevention and control they set up in 1953, under the chairmanship of Dr. W. H. J. Vernon, O.B.E., an Education Panel that is still active in listing all known courses in corrosion science, and in helping to provide lecturers for special courses on corrosion and for the programmes of technical societies.

With the exception of Cambridge, whose Emeritus Reader in the Science of Metallic Corrosion, Dr. U. R. Evans, F.R.S., has been the recipient of much international recognition, the universities have done little to stress the importance of fighting corrosion during recent years. Practical engineers in charge of industrial, locomotive or marine boilers know all too well the key significance of boiler water treatment in fighting corrosion; that is already the subject of British Standard Specifications but in academic establishments it has been nobody's business. Corrosion prevention and control has not been easy to fit into the academic departments of Chemistry, Engineering or Metallurgy although it must call on all three of them and without it modern power houses and ships could not operate. Now the University of Manchester gives "status" to such study by establishing corrosion science teaching laboratories and publishing its outline of syllabus.

In doing so it has recognised that the key to the problem of reducing the enormous cost of corrosion lies in the simultaneous development of research and teaching. Since the 1920's, when the Institute of Metals Corrosion Committee was fighting the corrosion of condenser tubes and the Iron and Steel Institute was setting up its corrosion committee, which was later handed over to B.I.S.R.A., there has been a steadily increasing awareness of corrosion.

Consequently the laboratories of the D.S.I.R., of government departments, and of industry and many teaching establishments now have available posts that should be filled by properly trained corrosionists. This new Manchester degree in Corrosion Science should therefore earn consideration in numerous appointments.

A specialist course of this type is not easily compared with what is offered elsewhere because the practices at each teaching establishment must be subject to change and development and depend so much year by year on the availability of enthusiastic teachers. There now seem to be three types of training in corrosion science available in Manchester University.

Firstly, undergraduates in the Chemical Engineering Department may study corrosion engineering as a final year special topic. Engineers so trained to have a basic appreciation of corrosion and its prevention should later contribute usefully to the better design and operation of plant and machinery in the chemical industries. Secondly, the Department includes an active post-graduate school which conducts research into the fundamental aspects of corrosion. At present the subjects being investigated in this manner include corrosion of metals by sulphur-containing gases; electrochemical role of protective coatings; behaviour of inhibitors in circulating systems; cathodic protection of heat exchangers; corrosion in moving environments; and related topics that are of undoubted interest to engineers. Thirdly, the need for training adequately qualified graduates in corrosion science has led to this new course in which, after lectures and laboratory work that lead to examinations in June or July, candidates must submit a dissertation for the higher degree of M.Sc. Tech. in Corrosion Science, during the following October or May.

This new degree course has been organised in the Department of Chemical Engineering, Fuel Technology and Metallurgy under Professor F. Morton. The staff most directly concerned includes Dr. T. K. Ross, M.I.Chem.E., A.M.Inst.F., Reader in Chemical Engineering in the University and in the College, who was in the Department of Chemical Engineering, University of Birmingham when he first joined the Corrosion Group half a dozen years ago. He was one of those who attended the very successful first international congress on Metallic Corrosion, as did his colleague Dr. I. A. Menzies, Lecturer in Metallurgy in the University and in the College. They will be assisted by two other lecturers, Dr. B. Gay and Mr. J. Postlethwaite.

Beryllium

A steely-white metal akin to magnesium, beryllium is similar to aluminium but one-third lighter with a specific gravity of 1·82, and 1284 deg. Cent. as its melting point. Forty years ago only the far-seeing Professor Goldschmidt, and perhaps Jules Verne, imagined that this chemical element, which existed in such rare and exotic gems as emerald and aquamarine, would be used in components of submarine-launched "Polaris" missiles. Beryllium is now used structurally in military missiles and earth satellites because low specific gravity in missiles means high range and large payload. It has been extracted from beryl and obtained as a by-product from felspar, mica, and lithium ores.

The recent International Conference on the Metallurgy of Beryllium, arranged by the Nuclear Energy Committee of the Institute of Metals, was an outstanding success. Older metallurgists and engineers were indeed surprised to find more than 250 delegates registered for this conference of specialists that was held at the Royal Commonwealth Society in London, October 16 to 18, 1961. From the U.K. there were some 170 delegates, their varied activities being scattered all over the country; more than forty came over from the U.S.A. and some twenty from France. Others came from Canada, Germany, Netherlands, Russia, Switzerland, Austria, Italy and Australia. The registration fee for this conference being £12 only those seriously interested are likely to have attended; it is, therefore, clear that beryllium has suddenly become highly important to quite a number of people.

Until 1956 the use of metallic beryllium was limited to such fields as alloying, X-ray tube applications, electrodes for neon lights, and for targets in cyclotrons. Its main use was probably as a deoxidiser for copper and as a constituent of various copper and nickel alloys. Beryllium bronze had become well established for springs, and beryllium copper was used for springs, wire and non-magnetic components. Up till then structural use of beryllium was prohibited by high cost, low ductility, notch sensitivity, and unfortunately also by toxicity.

The atomic energy field has become the greatest user of beryllium, followed by the missile makers, because many of the original problems have been solved by the intensive and costly research programmes of the past five years. Hence the feasibility has been established of using beryllium for structural components of missiles and spacecraft. Very expensive as beryllium still is, it will find applications in designs where its superior thermal characteristics justify its cost.

When in the near future the seventy papers of this international conference have been published, with accounts of their discussion, much quite new knowledge about this formerly exotic metal will be made public.

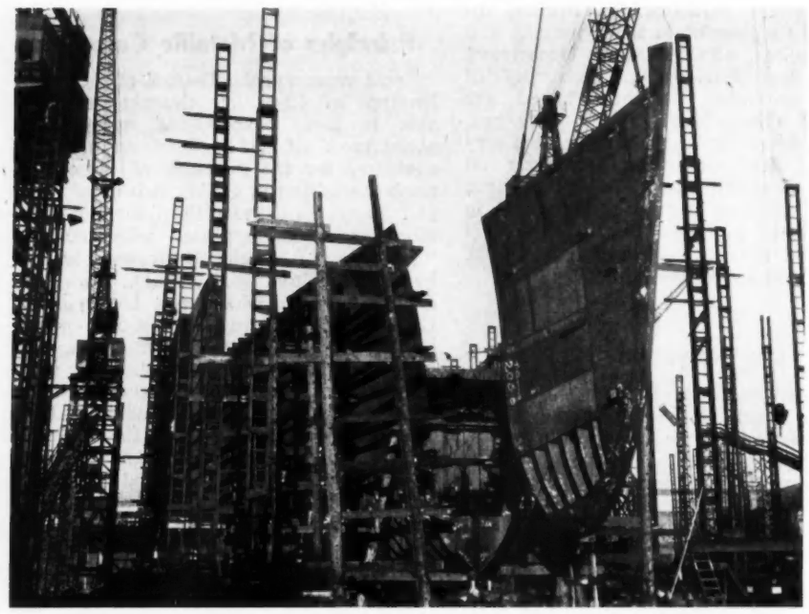
Principles of Metallic Corrosion

Some years ago the Council of the Royal Institute of Chemistry thought it desirable to issue concise and authoritative accounts of selected well-defined topics in chemistry for the guidance of those who teach the subject at G.C.E. Advanced Level and above. This year the fourth of these monographs has appeared with the title "Principles of Metallic Corrosion," written by J. P. Chilton, M.A., Ph.D., University Demonstrator in Metallurgy, University of Cambridge. It is an 8½in by 5½in paper-backed booklet of sixty-four pages, and many of the experiments described in it form part of the practical course in Metallurgy at Cambridge, in Part 1 of the Natural Sciences Tripos, and stem from the admirable early work of Dr. U. R. Evans and later teaching by Dr. T. P. Hoar and Mr. G. C. Smith. It has been preceded in this series by three monographs that dealt respectively with "Principles of Electrolysis," "Oxidation and Reduction," and "Extraction of Metals"; future titles in preparation are "Chemical Equilibrium," "Volumetric Analysis" and "The Colloidal State."

The establishment by the Royal Institute of a fund for the development of education in chemistry, and the encouragement of the Science Masters Association made it possible to go ahead with this series, the first two of which were priced at 3s. 6d., and the third and this, the fourth, at 6s. per copy. Although it was written primarily for the use of teachers of chemistry this particular monograph will be of value to engineer apprentices, who are often regrettably ignorant of the way in which chemists regard the materials that are used by engineers. It treats the subject under four main headings—(1) Corrosion of metals in gasesous environments; (2) Corrosion of metals in aqueous environments; (3) Prevention of corrosion; (4) Some further corrosion phenomena—and it gives suggestions for further reading. Lecturers in the engineering departments of colleges should find this handy little book authoritative.

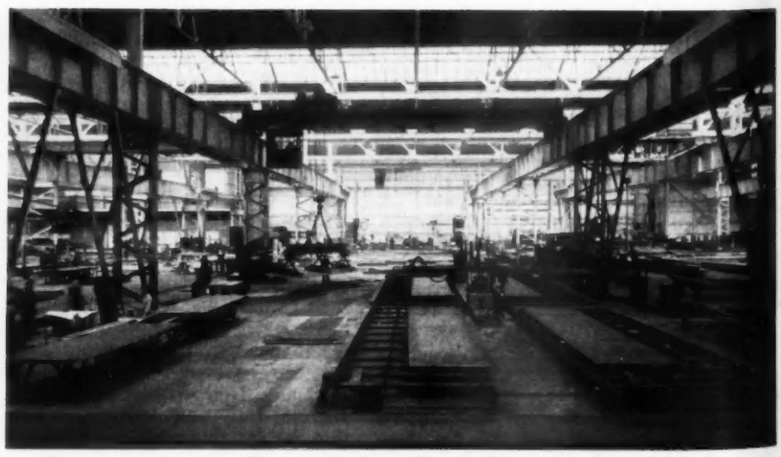
Modernised British Shipyards

The aerial photograph on the RIGHT of the yard of Austin and Pickergill Ltd. of Sunderland shows the three new berths in the west yard which can handle prefabricated units up to 30 tons and which have been laid out to eliminate unnecessary effort and attain economic building costs. To this end the material flow has been carefully planned and the fabricating, assembly and welding bays placed under one roof. A new fitting out quay and associated shops have been provided in the east yard while the removal of a ballast hill has provided an additional area which can be used for future expansion.



The throughput of the yard was 8900 tons in 1958 and 18,000 tons in 1960 and as a result of modernisation building times have been reduced, the following being examples of current achievements : dry cargo ships of 12,000 tons deadweight twenty-one weeks from laying of keel to delivery, 18,500 tons deadweight ore carrier 11½ weeks on berth, and 12,000 tons deadweight cargo ship at sea twenty-nine days after launching.

The illustration on the LEFT shows a bow section being mated with the remainder of a ship on the stocks at the yard of Hawthorn, Leslie (Shipbuilders) Ltd., Hebburn. There are three berths, two of which are manned at one time, served by 35 ton and 15 ton Monotower cranes and capable of taking tankers of 45,000 tons deadweight, while land has been acquired to lay down a berth able to take 60,000 tons deadweight tankers. Planned throughput is 25,000 tons of steel per annum, and the work is subject to a master control system together with departmental controls with the object of avoiding interruption of production. Land contours did not permit the Hebburn yard to plan for full flow production when considering reorganisation but by excavation it was possible to procure depth of site on various levels and so assist in material distribution. Plates measuring 45ft by 12ft and weighing 10 tons are handled by a magnetic lifting system and by powered bogies and all steel is shot blasted. In the plate preparation bays are flame planing machines, power driven conveyors, and a Schicham Monopol profile gas cutting machine which can be seen in our illustration RIGHT, in which the burners are guided by photo electric means from a hundredth scale negative taken from a tenth scale drawing prepared by loftsmen. Other machines in the bays include conventional equipment such as a mechanical edge planer, plate rolls, 300 tons and 1200 ton presses. Specially constructed facilities together with a 30 ton overhead travelling crane enable large panels to be turned over for back welding. Sections are bent cold and shot blasted, and bevelling of frames eliminated by welding to shell. There are two fabrication bays in which units of up to 40 tons weight are erected, and space alongside the berths provides for the storage of units and ensures stability in the steel trades.



American Spaceflight Meetings

By G. V. E. THOMPSON, B.Sc. (Eng.), F.B.I.S.

No. I

Two memorable meetings on spaceflight took place in America recently. The Twelfth International Astronautical Congress, which was held in Washington, D.C., on October 1 to 7, was organised by the American Rocket Society in association with the Aerospace Medical Association and the American Astronautical Society. It was eclipsed the following week by the American Rocket Society's Space Flight Report to the Nation, a mammoth meeting in New York, accompanied by an unparalleled exhibition at which were displayed present and prototype space capsules, spacecraft, satellites, boosters, missiles and components. The exhibition was later opened to the public ; there were over 5000 professional registrations for the meeting itself. Only the more important engineering aspects are dealt with below.

THE opening ceremony of the Twelfth International Congress was held in the auditorium of the Natural History Building, Smithsonian Institution, Washington, D.C. After an address of welcome by the Chairman of the Organising Committee, Professor Samuel Herrick, the Congress was declared open by the President of the International Astronautical Federation, Academician Leonid I. Sedov (Chairman of the Commission on Interplanetary Travel, U.S.S.R. Academy of Sciences), who traced the achievements of the first four years of astronautics and referred to future projects whose results would soon astound the world. In this field international co-operation on a world scale was greatly needed, but was limited at present. One major task of the I.A.F. was to promote such co-operation.

There followed an address by Dr. Hugh L. Dryden, Deputy Administrator of the National Aeronautics and Space Administration, who is thus civil service head of the U.S. government's civilian space effort, the Administrator of N.A.S.A. being a political appointment. He also stressed the need for global co-operation in astronautics.

For ages the explorer was restricted to the surface of the Earth, but in the eighteenth century he left the Earth's surface for the first time in a hot air balloon, soon rising to heights of a few miles. Then on December 17, 1903, centuries after the first legends of human flight, Man left the surface in controlled flight in a relatively fragile vehicle of wood, wire and cloth. Exploration of space by unmanned vehicles began on October 4, 1957, when the first artificial satellite of the Earth, a man-made moon, was launched into orbit. So far, man has sent no less than sixty-five such artificial moons into orbit around the Earth and four in orbit around the Sun. The total weight of these objects is more than 75 tons, not much compared with the weight of the Moon, about 10^{20} tons, but an impressive beginning.

The International Astronautical Federation was founded in 1950. Article I of its first constitution stated that " the I.A.F. shall exist to promote and stimulate the achievement of spaceflight as a peaceful project." The first steps in accomplishing this aim had been taken and the necessity of continuing manned exploration was widely recognised. Thus in a recent policy statement the Space Science Board of the National Academy of Sciences strongly emphasised that " planning for scientific exploration of the Moon and planets must at once be developed on the premise that Man will participate. Man can contribute critical elements of scientific judgment and discrimination in conducting the scientific exploration of these bodies which can never be fully supplied by his instruments, however complex and sophisticated they may become."

The proposed new draft of the constitution listed as the first objective : " To advance the development of astronautics for peaceful purposes." This change gave recognition to the manner in which astronautics had actually developed in its first four years. In addition to activities in the manned exploration of space, much progress had been made in space science and technology and their application to practical use in weather, communication and navigation satellites. The principal peaceful use, in addition to scientific investigation, which had advanced greatly during the first four years, was the application of weather satellites to global cloud observation and weather forecasting. During the week of November 13, the representatives of the meteorological services of more than twenty-five nations would assemble to participate in a *workshop* in which they would observe the reception of cloud photographs from the current weather satellite, if it was still performing satisfactorily. They would be given practical training in the interpretation of the photographs, so that on returning home they would be able to make effective use of data transmitted to them in day-to-day forecasting.

The Congress was a key factor in the prompt and widespread dissemination of information on astronautics to leading scientists, engineers and other professionals of the world. This process would be effective to the extent that space activities were carried on in the open and the results shared with the world community. Scientists and engineers needed complete and detailed quantitative reporting. The interplay of free analysis and discussion by the leading research workers of the world led to more rapid progress in every country because new results might appear anywhere within the tremendous range and scope of scientific and engineering knowledge underlying the exploration of space.

Dr. Dryden went on to say that space exploration had advanced from the realm of phantasy and dream through the stage of discussion of conceptual schemes to a demonstration of technical feasibility. The greatest needs of the immediate future were the stimulation of widespread public support nationally and internationally, and the achievement of co-operative efforts on a global scale.

Widespread public support required a major effort from all to interpret to people of many backgrounds not only the " how " but also the " why " of space exploration. To describe our objective merely in terms of a technical task, i.e. to send a three-man expedition to explore the Moon, failed to secure the support of many. We must explain again and again the role in a scientific and technological age of an activity which catalyses and integrates the expansion of the frontiers of knowledge. The real values lay in the major development in science and technology applicable to what man would do in space rather than in the mere accomplishment of man setting foot on the Moon.

The large sums of money required in this effort were not spent in outer space or on the Moon ; they were spent in the factories, workshops and laboratories for salaries, materials and supplies. The new knowledge and experience were transferable to other areas of industry, as in the past in the development of the automobile, aeroplane and nuclear reactor. Education would profit. Society would gain through the discipline of co-operation in a major task. We needed to convince the public, that the exploration of space was an activity of critical importance for the future of science, industry, education and public welfare in every nation, and that funds so spent would return benefits manyfold. Perhaps the lessons of the history of aeronautics might help.

Before closing the meeting, Professor Herrick asked for some provocative questions. A British delegate pointed out that the U.S.S.R. had boosters capable of launching heavy loads into space, while the U.S.A. had developed many types of instrument for research in space, and asked whether it would not be possible for Russia to send up one of their big rockets with a large load of American instruments. Dr. Dryden replied that he had already had words in private with Professor Sedov on this possibility, and if the decision rested with them alone, something along these lines would be done. Professor Sedov smilingly agreed and for a moment the audience was able to forget the cold war outside.

The lecture sessions were held in the Marriott Twin Bridges Motor Hotel, situated just outside Washington across the Potomac River, on Highway U.S.1 opposite the Pentagon. Claimed to be the world's largest motel, this proved to be a suitable (if expensive) headquarters, though some special arrangements had to be made because it was in Virginia, a relatively " dry " state. The organisation of the lectures was amorphous : as many as five sessions were run simultaneously, preprints were not generally available, and there were several changes of programme, so that it is difficult to determine just how many papers were presented. However, the number seems to have been well over 100, apart from unscripted contributions given at various " round tables " on specialised topics.

Propulsion Systems

The honour of giving the opening lecture fell to A. W. T. Mottram, of Bristol Siddeley Engines Ltd. (Coventry), who discussed the propulsion of the final stage of a satellite launcher using liquid hydrogen as fuel. Naturally, he was concerned with the final stage of the proposed European three-stage launcher based on " Blue Streak," and he took for mission the launching of a communications satellite into a high circular polar orbit at an altitude of 5000 miles with the highest possible precision. The need for accurate injection into orbit made the use of a low-thrust vernier phase injection attractive, and Mr. Mottram suggested that this phase should be extended to include one complete

circuit of the earth. The vehicle's being under power all the time would avoid the need for reorientation and relight after a coasting period, and the complete circuit would mean that the final period of the trajectory (where maximum guidance accuracy is needed) would be within range of the launching site, so that most of the guidance equipment could be concentrated, with a consequent reduction in cost and communication difficulties.

The benefit to be gained by the use of liquid hydrogen is seen by comparing the useful payload of 1015 lb with that obtainable in the same orbit using hydrogen peroxide/kerosene—600 lb (by using four stages). Further evidence of the importance of this fuel was given by Mr. Mottram : addition of a liquid hydrogen second-stage to an improved " Black Knight " research rocket would enable a payload of 300 lb to be placed in a 300-mile orbit by the two-stage vehicle.

Dr. Harold B. Finger, who is both Assistant Director for Nuclear Applications (N.A.S.A.) and Manager of the A.E.C.–N.A.S.A. Space Nuclear Propulsion Office, reviewed the status of the U.S. nuclear rocket programme. The justification for development of nuclear rocket propulsion systems is found in the analysis of manned planetary missions. Thus a spacecraft massing 9,000,000 lb in an orbit round the earth is needed for the return trip to Mars if only chemical propulsion is employed ; this may prove impractical. If nuclear rocket engines are used, the mass is reduced to about 900,000 lb and the money saved is claimed to be more than enough to pay the development cost of the engines.

Several nuclear systems have been proposed ; the two that are receiving major emphasis in the United States are the nuclear heat transfer rocket (Project " Rover ") and various nuclear-powered electrical propulsion systems. Greatest emphasis is being placed on " Rover," and the programme involves ground tests of reactors, the development of the N.E.R.V.A. (Nuclear Engine for Rocket Vehicle Application) engine, the R.I.F.T. (Reactor in Flight Test) study programme, safety investigations, and work in associated areas of advanced technology.

" Kiwi-A " reactor experiments were carried out successfully at the Nevada Test Site in 1959 and 1960. Plans for additional (" Kiwi-B ") reactor experiments were established and the test facilities are nearly complete. In 1962 an industrial contractor will begin development activities on a R.I.F.T.-vehicle to be flight tested in 1966–67. According to current ideas, the initial flight test will be accomplished by use of a " Saturn "-class first stage to launch the nuclear system on a short-range ballistic flight from the Atlantic Missile Range. Later tests will involve escape missions and orbital starts, followed by operational space applications.

The technology is so advanced that the development period is necessarily long. In this field, the U.S. seems far ahead, having already put into practice what has elsewhere only been talked about. However, it is impossible not to wonder whether the Russians may not have worked hard in secret and be even nearer towards flight testing a nuclear engine.

Dr. W. F. Hilton read a paper by P. A. E. Stewart and J. F. Swale (all of the Astronautics Group, Hawker Siddeley Aviation Ltd.) examining all the characteristics of several types of propulsion system (chemical, solar, nuclear thermal, nuclear electrical) and assessing their relative merits in application to transfer from low circular orbit (300 miles altitude) to a synchronous equatorial orbit. The latter is at an altitude of 22,000 miles, with a period of twenty-four hours, so that a satellite remains " stationary " above a point on the surface—of importance for certain communications purposes. The authors concluded that nuclear-powered propulsion systems would be advantageous when the payload could use the nuclear power after establishment in orbit, e.g., for broadband radio communications. Solar-powered units would be restricted in usefulness to missions in which journey times of several weeks could be tolerated. When avoidance of the van Allen radiation belts was of paramount importance, only chemical rockets employing high-performance liquid fuels would be useful.

Structures and Materials

The Structures session opened with a review of the structural design of the S-IV stage of the " Saturn " space exploration vehicle, given by L. H. Abraham of Douglas Aircraft Company. The " Saturn " is the largest U.S. rocket vehicle to have passed the drawing-board phase ; various versions of it are being developed. The first configuration (known as C-1) has three stages, the bottom stage being an eight-engined booster (S-1) developing 1,500,000 lb total thrust.

In the C-1 configuration the two upper stages are the Douglas S-IV and the Convair S-V. The Douglas stage employs four Pratt and Whitney LR-119 engines burning liquid hydrogen. Mr. Abraham described design criteria, the structural analysis, manufacturing considerations and ground handling problems for this stage. Two problems which loomed large in the task were the free-standing capabilities of an unpressurised large thin shell, and the separation of two cryogenic fluids (liquid hydrogen and liquid oxygen) by a common bulkhead.

An important contribution was given by L. D. Jaffe and J. B. Rittenhouse (Jet Propulsion Laboratory, California Institute of Technology), who reviewed materials problems in space. These arise both from vacuum and from collisions with particles. Evaporation and sublimation of inorganic materials in the vacuum of space can be treated by kinetic theory and thermodynamic methods, as the pertinent vapour pressures are generally known. Table I gives results for many elements of engineering interest, and shows that cadmium and zinc platings will be lost through sublimation at temperatures likely to be encountered in service. Metals such as aluminium, and semi-conductors such as germanium and silicon will not be appreciably affected. Magnesium will be lost at high service temperatures only. The problems of redeposition and of compound decomposition were also considered in the paper.

TABLE I—*Evaporation of Metals and Semi-conductors in High Vacuum*

Element	Temperature (deg. Cent.) at which evaporation is		
	10^{-4}cm/yr	10^{-3}cm/yr	10^{-2}cm/yr
Cadmium	40	80	120
Selenium	50	90	120
Zinc	70	130	180
Magnesium	130	180	240
Lithium	150	210	280
Lead	270	330	430
Indium	400	500	610
Silver	480	590	710
Tin	550	660	800
Aluminium	550	680	810
Beryllium	620	700	840
Copper	630	760	900
Gold	660	800	950
Germanium	660	800	950
Chromium	750	870	1000
Iron	770	900	1050
Silicon	790	920	1080
Nickel	800	940	1090
Titanium	920	1070	1250
Zirconium	1280	1500	1740
Molybdenum	1380	1630	1900
Carbon	1530	1680	1880
Tantalum	1780	2050	2360
Tungsten	1900	2150	2500

The vacuum behaviour of high polymers must be treated in a different fashion because the large polymer molecules break down into volatile fragments. Table II summarises

TABLE II—*Decomposition of Polymers in High Vacuum*

Polymer	Temperature for 10 per cent mass loss per year in vacuum, deg. Cent.
Nylon	30–210
Sulphide	40
Cellulose nitrate	40
Methyl acrylate	40–150
Ester	40–240
Epoxy	40–240
Urethane	70–150
Vinyl butyral	80
Vinyl chloride	90
Linseed oil	90
Neoprene (chloroprene)	90
Alkyd	90–150
Methyl methacrylate	100–200
Acrylonitrile	120
Isobutylene-isoprene (butyl rubber)	120
Styrene-butadiene	130
Styrene	130–220
Phenolic	130–270
Butadiene-acrylonitrile (nitrile rubber)	150–230
Vinyl alcohol	150
Vinyl acetate	160
Cellulose acetate butyrate	170
Cellulose	180
Carbonate	180
Methyl styrene	180–220
Cellulose acetate	190
Propylene	190–240
Rubber, natural	190
Isoprene	190
Silicone elastomer	200
Ethylene terephthalate (Mylar, Dacron)	200
Vinyl toluene	200
Styrene, cross-linked	230–250
Butadiene-styrene (GR-S—SBR)	240
Vinyl fluoride	240
Ethylene, low-density	240–280
Butadiene	250
Vinylidene fluoride-hexafluoropropene	250
Chlorotrifluoroethylene	250
Vinylidene fluoride	270
Ethylene, high-density	290
Tetrafluoroethylene	380
Methyl phenyl silicone resin	>380

results of experiments ; nylon, polysulphides, polyurethanes, P.V.C. and " Neoprene " may be significantly affected near room temperature. Polyethylene, polypropylene, chlorotrifluoethylene, vinylidene fluoride, P.T.F.E. and silicone resins are stable in vacuum up to 240 deg. Cent.

Friction and lubrication present a serious problem in the design of moving parts for space applications. The authors studied both the vacuum evaporation and creep of oils and volatile constituents of greases, and the behaviour of clean interacting surfaces free from adsorbed films. Laboratory tests showed that ball bearings with properly adjusted tolerances could be run at 10^{-5}mm Hg or lower for times of 1000 hours, using either certain low-vapour-pressure silicone-base, petroleum-base, or ester-base oils or greases, or properly applied thin solid films of silver, gold, molybdenum disulphide or P.T.F.E.

The effects of solar ultra-violet radiation in space differ somewhat from those on the earth's surface because of the absence of oxygen : polymers are more likely to undergo cross-linking and accompanying hardening rather than fragmentation and softening. Colour centres may develop in oxide pigments, causing a yellowing of white paints, which may affect temperature control of spacecraft. Solar radiation below 1000 Å may be especially important in affecting the paint vehicles, but this has not yet been simulated in laboratory tests.

In the past, concern has been expressed over the possibility of material being removed by collision with low-energy ions and atoms in space (sputtering), but this does not now

TABLE III—*Permanent Damage to Engineering Properties of Materials by Radiation in Space*
(Exposure time : months to years)

Material	Inner Radiation belt		Outer radiation belt		Solar corpuscular emission		Solar electro-magnetic radiation	
	Through 1mg/cm²	Through 1g/cm²	Through 1mg/cm²	Through 1g/cm²	Through 1mg/cm²	Through 1g/cm²	Through 1mg/cm²	Through 1g/cm²
Polymers	All	Some	All	Some	Some	None	Some	None
Oils and greases	All	None	All	None	None	None	None	None
Ceramics :								
Optical properties	All	Some	All	Some	Some	Some	Some	None
Other properties	All	None	Some	None	None*	None	None	None
Semi-conductors :								
Minority carrier effects	All	All	Some	None	Some	Some	None	None
Majority carrier effects	All	Some	None	None	None*	None	None	None
Metals	All	None	None	None	None*	None	None	None

* Extreme surface may be affected.

TABLE IV—*Radiation Dosage in Space*

Radiation	Ionisation, erg g⁻¹ year⁻¹			Fraction of atoms displaced per year		
	Exposed surface	Through 1mg/cm²	Through 1g/cm²	Exposed surface	Through 1mg/cm²	Through 1g/cm²
Inner radiation belt	10^{14}(?)	10^{14}	10^{7}–10^{8}	10^{-1} (?)	10^{-6}	10^{-9}
Outer radiation belt	10^{13}–10^{15}	10^{13}–10^{15}	10^{6}–10^{9}	10^{-12}–10^{-10}	10^{-13}–10^{-10}	10^{-15}
Solar flares and steady emission	$<10^{15}$	10^{8}–10^{9}	10^{8}–10^{9}	10–1	10^{-13}–10^{-11}	10^{-15}–10^{-11}
Cosmic rays	10^{3}–10^{9}	10^{3}–10^{9}	10^{3}–10^{9}	10^{-14}–10^{-14}	10^{-15}–10^{-14}	10^{-15}–10^{-14}

appear to be of engineering importance. Higher-energy ions and electrons may cause radiation damage. The authors discussed the effect to be expected in terms of the ionisation or displacement of atoms in materials and change in properties involved (see Table III), the location of the materials in the spacecraft, and the location of the spacecraft in space (see Table IV). The surfaces of organic materials or glasses can be seriously damaged in the radiation belts and probably also by solar flares. Metals are unlikely to undergo damage, except possibly to their magnetic properties. Semi-conductors will also be affected in the radiation belts and may be affected by solar flares.

Data on erosion and penetration rates from meteoric impact near and away from the earth were given, the importance of rear-surface spalling being stressed. To prevent spalling, thicknesses may have to be twice as great as to prevent penetration ; for both, substantial mass reduction may be achieved by use of spaced armour (bumpers), and the necessary bumper thicknesses and spacing were given.

G. L. Grodzovskii (U.S.S.R.) discussed the optimum contour for heat rejection fins cooled by radiation, for the case of heat supply from one side, and showed that it consisted of two regions ; that of constant (prescribed minimum) thickness close to the tip, and the region of extremum contour with tip temperatures prescribed. Longitudinal cambering of heat rejection fins cooling the gas flow in a cylindrical tube was also considered. The other papers presented at this session were " Review of Methods of Composite Construction," by B. R. Noton (Aeronautical Research Institute of Sweden), and " Review of Recent Studies of Crack Propagation," by A. J. Murphy (Principal, College of Aeronautics, Cranfield).

Energy Conversion

Energy conversion is of fundamental importance in many branches of engineering, and a session was devoted to it. Two of the papers concerned fuel cells.

Ernst M. Cohn of the U.S. Army Research Office reviewed progress in this field and indicated the problems still awaiting solution. He said that a large part of the interest in fuel cells in recent years has resulted from their potentialities as power sources for space vehicles. The year 1960 was probably the year of greatest upswing in fuel-cell activities, with many new organisations entering the field, but 1961 had brought no particularly startling developments except for the concept of the biochemical fuel cell. It had been established that further effort on certain types of cell (e.g., redox) was not warranted, at least at present, but progress along other lines (particularly hydrogen-oxygen systems) made it seem likely that some model cells would be flight tested next year. The U.S. General Electric Company has exhibited a Navy- and Army-sponsored 200W unit that works on hydrogen and air with cationic membranes as electrolyte.

In one Army contract, Speer Carbon Company is studying methods of preparing porous carbon electrodes with a narrow range of pore sizes (mostly 2 to 4 microns) and surface areas from 50 to 200m² g⁻¹. Preliminary results indicate that materials that are highly graphitised are not well suited for use in fuel cells.

No spectacular advances have been made in using hydrocarbon fuels in low-temperature cells, but much has been learned about the electro-chemical behaviour of the lower alcohols and their oxidation products. Mr. Cohn mentioned the successful operation at Sondes Place Research Institute here of high-temperature fuel cells using methane or propane pre-reacted in a steam reformer ; these had been operated for 1000 hours at 650 deg. Cent. with a current density of 75mA per square centimetre at 0·8V.

Although work in England on the primary Bacon fuel cell was stopped some time ago, mostly for economic reasons, Pratt and Whitney have been working on the regenerator portion of a 500W hydrogen-oxygen Bacon cell. The study was undertaken for the U.S. Signal Corps and a system has been devised that is operable at zero gravity.

Two sodium amalgam consumable-electrode cells are being studied. Dr. Smatko's sodium-chlorine cell is in the research stage ; current densities up to 250mA per square centimetre have been obtained, with voltages of about 1V for chlorine (>2V for bromine). Professor Yeager's sodium-oxygen cell is now being scaled up for the U.S. Navy to a 75kW unit by the M. W. Kellogg Company. It is said to weigh 2 lb to 3 lb per kilowatt hour, including fuel storage, and operates at atmospheric pressure and 60 deg. Cent.

Research on the biochemical fuel cell appears to be branching out into three distinct directions : (1) attempts at imitation of biological processes ; (2) possible *in vitro* use of biological materials as catalysts, and (3) utilisation of primitive forms of life to decompose organic matter and obtain fluid fuels suitable for use in fuel cells.

Prominent among fuel-cell problems for low-temperature systems is the need for (1) highly active anode catalysts to realise a hydrocarbon fuel cell ; (2) sulphur-resistant catalysts to permit the use of impure gases, and (3) highly active cathode catalysts for using air as the oxidant. The problems of fused-carbonate, high-temperature cells are mainly those concerned with corrosion, maintenance of contact between electrode and electrolyte, and methods and materials of construction. The main drawbacks to regenerative systems are polarisation losses, internal electrical resistance and complicated storage devices.

E. W. Justi and A. W. Winsel of the Braunschweig Institute of Technology, West Germany, reported work on high-drain fuel cells operating at ambient temperature. To combine the high catalytic activity and insensitivity to impurities of Raney nickel with the mechanical rigidity and electrical conductivity of bulk nickel, a double skeleton catalyst (D.S.K.) has been introduced. Uniform diameter grains of nickel-aluminium alloy are incorporated in the pores of a sponge-like macroskeleton pressed and sintered from carbonyl nickel powder of uniform particle size, the powders being mixed carefully by a special blending process. The sintered electrode is activated by dissolving the aluminium with hot potassium hydroxide to leave a residue of highly active pyrophoric microskeletons in the pores of the supporting macroskeleton.

The authors prepared more than 3000 different specimens to determine optimum conditions for the particle size of both grains, alloy composition, blending ratio, pressure and sintering temperature. The leaching temperature could be reduced and the activity improved by applying a positive potential during leaching. It was found possible to homogenise the pore diameter, the pore size being such as to prevent electrode flooding as well as leakage without electro-chemical reaction, and because of the homeo-porosity the current density on these monolayer hydrogen electrodes could be increased as high as 750mA per square centimetre with 40mV polarisation only at 80 deg. Cent., and up to 80 per cent gas consumption efficiency. 130mV polarisation has been obtained at 250mA per square centimetre and 100 per cent gas consumption, *iR* drop subtracted.

To get similarly good oxygen electrodes is much more difficult because the oxygen molecule needs more energy for dissociation. The authors have developed a new brittle Raney silver catalyst which can be milled and incorporated in a nickel macroskeleton by a special hot pressing process avoiding liquid metal phases. The resulting electrodes afford complete combustion at 85 deg. Cent., the final product being H_2O (the Berl process gives H_2O_2), so that each oxygen molecule delivers four electrons instead of the two in the Berl process. The polarisation is 100mV at zero current density, 400mV at 500mA per square centimetre.

Another type of D.S.K. system is the " dissolved-fuel fuel cell," in which liquid fuel such as methanol or ethylene glycol is dissolved in the electrolyte and dehydrogenated by the highly active anode. It is not yet completely engineered, but special systems have been developed to remove continuous reaction products such as water and carbonates.

The authors also claim to have developed a new method of storing hydrogen at atmospheric pressure between 20 deg. and 30 deg. Cent. in a semi-liquid state. The figures quoted are 4·3 kg or 0·49 litres net per cubic metre of hydrogen at N.T.P. (compared with 6·0 kg or 5 litres for hydrogen compressed

at 100 atmospheres). Details are to be released next year, and it is expected that this will greatly favour the use of hydrogen as a fuel.

This work is to be intensified in collaboration with Accumulatoren Fabrik A.G., Frankfurt, and Siemens Schuckertwerke A.G., Earlangen.

In a review of the present status of the technology of and future requirements for solar direct conversion power systems for use in spacecraft, W. C. Cooley (Vice-President and Technical Director, Exotech Inc., Alexandria, Virginia) suggested that silicon solar cells combined with batteries would continue to meet most requirements in the near future. The need for higher power systems (300W to 3000W capacity) would provide incentives for developing larger area solar cells and for concentrating the arrays and systems to reduce costs, improve reliability and decrease weight. For twenty-four hour satellites, the cells would have to be protected against electron radiation damage by a 0·065in layer of non-browning glass.

For satellites within the inner van Allen belt (600 to 5000 miles altitude), shielding against protons is impractical and there would be an appreciable drop in efficiency of silicon cells in a few months. Gallium arsenide cells would offer improved radiation resistance, but present production costs are high. There is a need for improved solar simulators and spectrophotometers for use in the large-scale testing of solar cells and radiation damage research.

It seems likely that with photo-emissive power conversion ultimate efficiencies of only 2 to 4 per cent may be attainable ; with thermoelectric materials overall efficiencies may reach 5 per cent. In both cases the large collector areas required as compared with solar cells make the systems less desirable. The development of thermionic converters is proceeding rapidly and it is expected that overall conversion efficiencies of 10 per cent or higher can be produced in the next few years. If this came about they would find application in planetary spacecraft, where continuous exposure to sunlight is possible. Practical application in earth satellites would require solution of thermal cycling problems or development of thermal energy storage materials and containment methods which would operate above 1300 deg. Cent. The potential advantages of solar-thermionic systems as compared with solar cell arrays include lower mass, lower cost, and insensitivity to both radiation damage and to high ambient temperatures (e.g., on the Moon). However, Sun orientation accuracy of about 0·1 deg. is required when using a paraboloidal collector of high concentration ratio. A comparison of the mass estimates for the various systems indicates that they are all closely competitive for power levels from 50W to 5000W, which Mr. Cooley thought would meet most of the spacecraft requirements during the next ten years.

P. H. Egli (U.S. Naval Research Laboratory) discussed in greater detail space power sources using the thermo-electric or thermionic emission processes, which he considered to be the most promising methods for direct conversion of heat into electricity. The two processes are more likely to be complementary than competitive, as the former is limited to temperatures that do not appreciably exceed 1200 deg. Cent. but the latter need a temperature in excess of 1000 deg. and preferably near 2000 deg. Cent. Ultimately the two processes may be operated in series, with the thermionic process converting high temperature heat and thermo-electricity recovering the heat rejected at lower temperatures.

Because most heat sources now available (particularly nuclear reactors) operate below 1000 deg. Cent. thermo-electricity is likely to find applications more quickly ; the first problem here is to develop efficient materials. The necessary properties represent a compromise : higher voltages are developed by insulators, but high electrical conductivity is required if the current is not to be dissipated in resistance heating ; a low thermal conductivity is necessary to minimise the flow of heat without production of work. The materials best meeting these conflicting requirements are intermediate between semiconductors and semi-metals, and nearly all the effort has been on their development. Progress has been encouraging. Early devices had an overall efficiency of 2 to 6 per cent, but theoretical efficiencies of better than 20 per cent can be shown and actual overall efficiencies of 15 to 16 per cent will soon be achieved.

No single material can be expected to operate well over the wide temperature range required for a reasonable Carnot efficiency, so that several materials must be used in a single couple. Because of simplicity, redundancy and lack of moving parts, thermo-electric devices offer the ultimate in reliability. Five or ten-year mean time to failure should be readily achievable by designing conservatively with respect to temperature limitations. For power supplies up to 5kW or 10kW the converter is only a small fraction of the total system mass and the reliability is difficult to match by other systems. The principle of the thermionic process is that a cathode is heated to incandescence so that it gives off electrons, which are collected by an opposing colder cathode ; a plasma-producing gas is normally introduced into the intermediate space to reduce the space charge effect. Several types of generator have been developed :

Vacuum Cell.—The electrode spacing is usually considerably less than 0·001in for high performance and the electrode surfaces are specially prepared (e.g., oxide coating). These allow the cell to be operated at low cathode temperatures (about 1100 deg. Cent.). The principal life determinants are warpage tolerances for the electrodes, and poisoning of the anode by material from the hotter cathode.

Low-Temperature Plasma Cell.—Space charge neutralisation is achieved by maintaining an appropriate positive ion density in the interelectrode region (usually caesium). Because the cathode temperature is low (about 1200 deg. Cent.) ion generation does not automatically occur at the surface, so auxiliary ion production methods are used, e.g. a third electrode, usually hotter and of higher work function than the cathode, and biased so that its surface potential is nearly equal to the electrostatic potential of the plasma.

Refractory Metal Plasma Cell.—The cathode is of a refractory metal (e.g. tungsten, tantalum, molybdenum or rhenium), and cathode and anode are coated with caesium (i.e. it is a "wet cell"). The operating temperature is high enough (about 1600 deg. Cent.) for ion generation to occur at the cathode surface. Operating requirements dictate a high caesium pressure and as a consequence close spacings (0·01in or less) are required to reduce electron scattering effects in the plasma.

Carbide Caesium Cell.—Ions are generated by the high temperature (1800 deg. Cent.) of the carbide cathode ; the anode work function is maintained by caesium wetting. Spacings are greater than in the wet cathode cell.

Small experimental thermionic generators have been operated in laboratories at 10 to 15 per cent overall efficiency, and it is expected that 25 per cent or higher will be achieved there in the next few years. The major problem in putting the devices into practical use is that of cathode life ; it is difficult to predict when cathodes with lives greater than a few thousand hours will be available.

The development of nuclear power in the U.S. for space applications was surveyed by Lt.-Col. G. M. Anderson and Commander D. L. Jarrell of the U.S. Atomic Energy Commission. The present version of the first nuclear electric propulsion system (by A.E.C. and N.A.S.A.) is called the "Snap-8." This will have either 30kW or 60kW output at a specific mass of 50 lb to 70 lb per kilowatt. Ground tests of the initial system should take place in 1962. Ultimate specific masses of 10 lb to 20 lb per kilowatt will require high-temperature Rankine-cycle turbo-generators or thermionic systems. Radiator size and mass become the controlling factor at power levels in the multi-kilowatt range, hence high temperatures are required to obtain minimum mass. Thermionic systems may feature the thermionic emitter as an integral part of the fuel rods or the conversion device may be part of the radiator.

Nuclear auxiliary power in space was first demonstrated by the radio-isotope power supply of the "Transit-4A" navigation satellite in June, 1961. The basic compact reactor for this purpose now under development is the "Snap-2" ; in this system heat from the reactor is transferred by liquid metal to boil mercury to the superheated state. This is used as the working fluid to drive an integral turbo-alternator to produce 3kW electrical power. The reactor employs a homogeneous fuel-moderator of zirconium hydride containing U235. Successful testing of the

TABLE V

Title	Type	Rating	Agency	Specific Fuel Consumption lb/h.p.-hr.	Specific Mass	Working Fluid	Duration hr.	Status
"Snap"-2	Nuclear	3kW (electrical)	A.E.C.	—	250 lb/kW	Mercury	10,000	Ground-tested
"Snap"-8	Nuclear	30kW (electrical)	A.E.C./ N.A.S.A.	—	47 lb/kW	Mercury	10,000	Component development
"Spur"	Nuclear	300kW (electrical)	U.S.A.F.	—	10 lb/kW	Potassium	10,000	Conceptural design completed
15kW	Solar	15kW (electrical)	U.S.A.F.	—	65 lb/kW	Rubidium	10,000	Initial component fabrication
"Sunflower" ...	Solar	3kW (electrical)	N.A.S.A.	—	250 lb/kW	Mercury	10,000	Development testing initiated
Stirling engine	Solar	3kW (electrical)	U.S.A.F.	—	170 lb/kW	Helium	10,000	Prototype under test
"Dynasoar" ...	Chemical	30 h.p.	U.S.A.F.	1·5	—	Hydrogen	250	Initial design and component test
Integrated power-cooling system	Chemical	15–40 h.p.	U.S.A.F.	1·5	150 lb*	Hydrogen	36	Prototype ready for test
"Cryhocycle" ...	Chemical (300 deg. Fah.)	8 h.p.	U.S.A.F.	1·5	80 lb*	Hydrogen	300	Initial design nearing completion
871A	Chemical	40 h.p.	U.S.A.F.	4	150 lb*	Hydrazine	50	Final design nearing completion

* Not including tank and fuel.

first reactor at design power of 50kW (thermal) was concluded after a year of operation in November, 1960. The second experimental reactor is now being tested.

An alternative system, "Snap-10A," couples the "Snap-2" reactor with thermoelectric conversion to produce 500W (electrical). This has no moving parts and will operate without positive control because of the strong negative temperature coefficient of resistivity inherent in the reactor design.

Uses of this power will include navigational satellites such as "Transit," weather satellites such as "Tiros," defence applications, lunar missions and the commercial satellite radio and television relay systems. Past experience has taught that power requirements continually increase and the authors feel that the present programme will provide only a part of the ultimate needs for exploration, hence there is a need to seek even higher power, high-temperature systems.

G. W. Sherman (U.S. Air Force) had prepared a forecast of the 1966 areas of optimum application of energy conversion systems (Fig. 1)—an integration of all

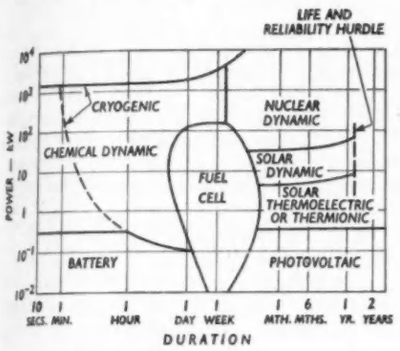


Fig. 1.

opinions expressed on this subject. Dynamic systems (employing reciprocating or turbine engines) are expected to play an important role in aerospace applications because of the extensive background experience in surface and atmospheric applications. He summarised the U.S. dynamic space power systems being developed (Table V).

The belt radiator is one of several concepts showing promise in the reduction of radiator masses, particularly in nuclear systems; waste heat is transferred to a moving solid body having sufficient thermal capacity to absorb it and reject it by radiation. Such a body should not require the heavy mechanical protection against meteoroid penetration needed in the case of conventional finned tube radiators.

Other Technical Sessions

The other lecture sessions were devoted to such topics as life sciences and bioastronautics, astrodynamics (orbit theory, guidance, control and geodesy), space law, combustion, radar and radio-astronomy, space communications (including a paper by J. W. Eerkens of Aerospace Corporation on the use of gamma rays for communications purposes), vehicles, instrumentation, &c.

(To be continued.)

Identity Marked Rubber Hose.—To facilitate the identification of rubber hoses used for conveying compressed air, water and steam, F. Reddaway and Co. Ltd., St. Anthony's, Newcastle upon Tyne, 6, has introduced "Spiraline" identity hose. This type of hose has a ¼in wide coloured spiral strip along its full length and forming an integral part of the cover. The colours are in accordance with B.S. 1710 : 1960, light blue for water, white for air, and red for steam. It is also available with yellow, green, brown and dark blue coloured strips for users who wish to indicate ownership.

Global Communication

In his chairman's address to the Electronics and Communications Section of the Institution of Electrical Engineers on October 25, Mr. R. J. Halsey, Director of Research, Post Office Engineering Department, reviewed the progress of world-wide communications by radio and cable. After describing the differences between British and American practice exemplified in the first transatlantic telephone cable, Mr. Halsey dealt with later development in both countries and the wider schemes now under way, concluding with an assessment of the future. Some passages from the later portion of the address are summarised below.

UNTIL the construction of TAT-1 [the first transatlantic telephone cable] it was assumed that, apart from temperature and pressure coefficients, the attenuation of coaxial cable was stable. TAT-1 laying trials revealed that there was, in fact, an anomalous decrease in attenuation of about 1·5 per cent on laying. Experience shows that this reduction continues after laying, and has so far amounted to 13 dB (0·4 per cent) at 164 kc/s; it can hardly level out at less than 16 dB. It appears to be due to the composite conductors, particularly the outer conductor with its overlapping binding tape, the components of which are pressed into more intimate contact as time proceeds; thus the effective current path becomes more nearly longitudinal and the resistance decreases. A new cable design should, therefore, have conductors with longitudinal (preferably) or stable helical paths. British Mark I [lightweight] cable has a longitudinal centre conductor, but, to ensure that it will pass round rotating machinery without damage, the outer conductor consists of six helical aluminium tapes which are self-insulating in respect of edge contacts. Because of leakage flux between these tapes, which is troublesome when the cable is coiled in the ship's tanks, a thin insulated screen is added.

In the Mark II cable, now under test, this complex structure is replaced by a single overlapping longitudinal aluminium tape, gripped firmly by the plastic sheath. Such cable is clearly more liable to damage on rotating machinery, but present indications are that it will be satisfactory.

Since the strength member of lightweight cable is at the centre, all laying, holding and recovery forces, which must be applied externally, must be sustained by shear forces in the cable structure; frictional resistance between the cable elements is therefore highly important.

In 1958 a Commonwealth Communications Conference in London evolved a plan for a Commonwealth round-the-world cable similar to and including CANTAT [the United Kingdom–Canada cable]; this would give alternative routeings in the event of a cable failure. The cable would cross the Pacific from Vancouver to New Zealand and Australia and thence to Malaya, Ceylon, India and Pakistan, to South Africa and back to the United Kingdom *via* West Africa and Gibraltar. The estimated cost was £88,000,000 for a total distance of nearly 30,000 nautical miles. This plan was accepted by the governments in 1959, and in the same year a conference in Sydney resulted in agreement to construct the Pacific section (COMPAC) from Vancouver to Sydney, for service early in 1964. It was agreed with the United States to land near Honolulu and there to interconnect with the A.T. and T. system existing and planned; the longest cable section will now be Honolulu–Fiji, some 3000 nautical miles. The first section, Sydney–Auckland, will be laid in June, 1962.

The next section of the round-the-world cable was the subject of a conference in Kuala Lumpur this year. Technical agreement was reached to provide a system (SEACOM) via New Guinea and North Borneo, with a spur from North Borneo to Hong Kong—a total of some 6300 nautical miles at depths of up to 4000 fathoms. This could be completed in 1965, but has not yet been agreed by governments.

Five Transatlantic Cables

By 1956 the Bell Telephone Laboratories had reoriented their ideas completely in respect of cable and repeater design, and accepted all the basic principles of the British system—two-way operation, type of valve, twin amplifiers, rigid repeaters and lightweight cable. By thorough and extensive development they have now evolved a system giving a bandwidth of 384 kc/s in each direction over a distance of 3500 nautical miles.

They have also adopted, and greatly improved on, caterpillar laying gear. An elegant machine has tracks which open up to "swallow" short repeaters; this avoids having two caterpillars. Such a laying engine will be fitted on a new A.T. and T. ship, which, in 1962, will lay the first new-type American system between the United States and Jamaica. In 1963 a similar cable will be laid direct from New Jersey to Cornwall, a distance of 3500 nautical miles (TAT-3)

The American lightweight cable, while based on our own, has its own novel features including a single longitudinal return tape as adopted for the British Mark II cable. The use of a linear laying engine involves greatly reduced cable-bending requirements, and a thin copper return tape is used satisfactorily.

After completion of TAT-3 the A.T. and T. plan to cross the Pacific Ocean, starting in 1963 with a cable which will, in 1964, connect to Guam, *via* Midway, and thence three ways to Japan, Okinawa and the Philippines. A second cable will also be laid from California to Honolulu, the interconnection point with COMPAC.

A system providing 24 circuits and required largely for control of civil air traffic (I.C.A.O.) is now being completed by H.M.T.S. "Alert" between Gairloch, Scotland, and Iceland via the Faroes (SCOTICE); this uses 0·46in armoured cable with twenty-five repeaters at depths of up to 1000 fathoms. In 1962 it will be extended to Newfoundland via Greenland by a German system (ICECAN), also now redesigned with rigid repeaters. This will give a total of five systems across the Atlantic and sufficient alternative routeing to make it reasonable to dispense with the h.f. radio circuits which have, so far, been kept in service.

The cable routes across the North Atlantic, the Commonwealth round-the-world system and American cables in the Pacific have been evolved to meet specific needs, and further planning will doubtless be largely inspired by similar considerations. Nevertheless, it is of interest to examine the pattern of the

global plan which is emerging—this could become two roughly east-west girdles with a number of north-south interconnections. Such a plan, carried to its logical conclusion, would give excellent alternative routeings in the event of cable failures.

A South Atlantic link from Ascension to Recife, Brazil, could reasonably come to fruition and thence could interconnect with the Caribbean cables at Trinidad. A South Pacific link from New Zealand to the west coast of South America with a transcontinental connection to Recife seems unlikely. Thus the northern and southern girdles come together and interconnect at Honolulu.

Overland Links

Overland cable and microwave radio-relay systems form essential parts of most systems which are primarily submarine cable, e.g., from London to Oban, and Nova Scotia to New York and Montreal in TAT-1 ; the trans-Canada system will be an essential interconnection between the CANTAT and COMPAC systems. It might, therefore, seem logical to establish major overland systems and, thereby, avoid the necessity for certain submarine cables. In general, however, long overland links are less suitable for inclusion in global circuits than submarine links in respect of net loss, stability and noise ; standards of maintenance in some of the under-developed countries may also be problematical. In more highly developed areas overland links should, however, be acceptable and, as an example, an overland connection between London and Malta might well supplement a future submarine cable link through the Mediterranean *via* Gibraltar. Similarly a trans-Siberian microwave system to Vladivostok might one day provide an alternative connection to the Far East.

Under N.A.T.O. auspices, a micro-wave link already joins Rome, Athens and Izmur (Asia Minor) and, under the Central Treaty Organisation, links are now being developed from Ankara to Teheran and Karachi. By the middle 1960's it may well be possible to make an overland call from London to West Pakistan, or even to India, but extenstion further east by this means is extremely doubtful.

The stability of submarine cable circuits is particularly good, and, even without automatic gain control, the standard deviation of attenuation on TAT-1 has been maintained to within 1·2 dB, i.e. better than most inland circuits in this country : this is improved substantially with group a.g.c. With such stability it is practicable to operate at about 0·5 dB loss in a transit connection or 6 dB in a terminated connection. The cost of long submarine systems is, however, so high that it is economic to spend a lot of money on terminal equipment for their more efficient usage. Measures so far adopted are :

(*a*) Highly efficient channelling equipment, developed by the Post Office, whereby a telephone circuit provided within 3 kc/s is virtually indistinguishable from that normally provided within 4 kc/s,

(*b*) A high-speed electronic switching system, developed by A.T. and T., whereby it is practicable for talkers to seize a telephone circuit only when they begin to speak ; this arrangement, time assignment speech interpolation (T.A.S.I.), is in use on TAT-1 and TAT-2, and approximately doubles the circuit capacity ;

(*c*) A time-division multiplex system whereby two fifty-band telegraph channels can be provided in each 120 c/s band, or alternatively four half-speed or eight quarter-speed channels.

The Future

Twenty-five years ago it appeared that cables must be unchallenged for communication overland and radiocommunication would be unchallenged across the oceans. Five years ago it seemed that just the reverse was true ; microwave radio-relay systems providing thousands of telephone circuits or their equivalent, were coming into increasing use on land, and world-wide ocean cable networks were being planned. Now, in 1961, we see signs of a possible further reversal ; namely, waveguides, a form of cable capable of providing tens of thousands of circuits over land, and radio-relay *via* earth satellites across the oceans.

It is too early to assess just what the impact of communication satellites will be. They have, of course, only become possible because of the vast military expenditure on means whereby they can be launched. That they will be capable of providing large numbers of communication channels, including television, once in orbit is undoubted ; what will be the service characteristics of those channels and the maintenance costs remain to be seen. One thing is certain : some much-publicised estimates of possible charges are far too low.

It is not my intention to discuss satellites, except to say that, for civil communication, active devices, capable of retransmitting signals and not merely reflecting them, will be used, and to mention the adverse reaction of telephone subscribers to excessive propagation times. The C.C.I.T.T. recommends that the one-way propagation time on an overall connection shall not exceed 250 ms (500 ms loop delay), and allocates 150 ms to the " international " link and 50 ms in the national circuit at each end ; these are realistic limits which cannot be ignored and which must impose restrictions on the altitude of satellites. The synchronous satellite which, at an altitude of 22,300 miles, maintains a stationary position relative to a point on the earth, involves a one-way propagation time of 125 ms, which might be acceptable ; the 250 ms involved in a two-hop connection to the antipodes would, however, be intolerable with limiting national extensions, the more so if " international continental " circuits are included. Thus lower-orbit non-stationary satellites appear to be essential on this account. Some difficulty may, indeed, arise with the longest submarine cable connections now planned, where, for example, a London–Singapore circuit *via* Sydney will involve a one-way propagation time of 180 ms.

Neither the Commonwealth nor the United States is, at this stage, cutting down on its plans for an ocean cable network. Rather, inspired by the technical challenge of communication satellites, each is thinking of what more is possible at the next stage of cable development. As far as the Commonwealth is concerned, this is likely to be a system providing a bandwidth of at least 750 kc/s in each direction over 2000 nautical miles, e.g. across the Atlantic. With suitable effort expended on terminal equipment, whereby redundant picture information is eliminated or reduced, such a system could well provide a " real-time " television service as well as telephony and telegraphy.

Plymstock Cement Works

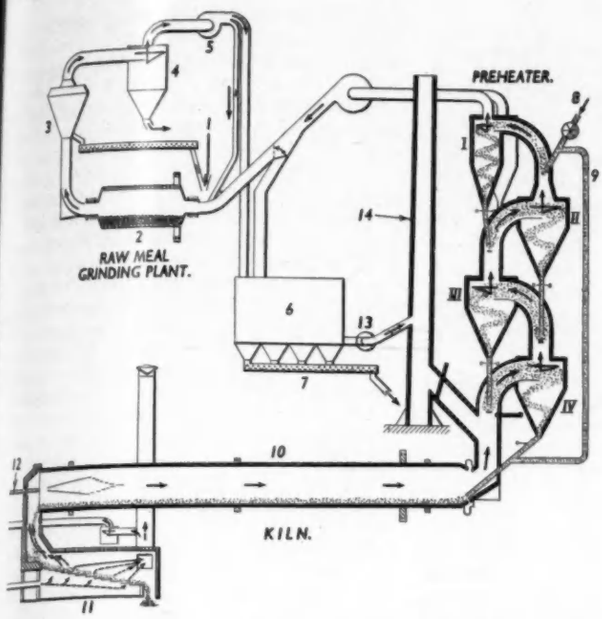
A new cement works with a single kiln and a production of about 220,000 *tons of cement a year was opened by Associated Portland Cement Manufacturers Ltd. last month at Plymstock in Devon. For the first time in this country, the Humboldt process is used at this works ; the process is " dry " and is characterised by the preheating of " raw meal " powder which is then fed directly to the kiln.*

ALTHOUGH reconstruction and improvement at the various works of the Blue Circle Group of cement manufacturers is going on more or less continuously, the construction of a completely new works is relatively rare. One such works, at Plymstock in Devon, has just been opened. Its design reflects the recent policy of the group of abandoning the " wet " process of cement manufacture which has been the traditional method in this country until recently, and of using instead the " dry " processes which are more economical in fuel consumption.

In 1957, the group completed a new works at Cauldon near Stoke-on-Trent, which introduced a " dry " process into this country for the first time. Cauldon works was described quite fully in THE ENGINEER of October 11, 1957. Since then, its output has been doubled by the installation of a second kiln, and all the equipment which that entails, and at present the installation of a third kiln is in progress. The process used at Cauldon is also referred to as the " Lepol " process and sometimes as the " semi-dry " process. Instead of the slurry which is fed to the kiln in the " wet " process, the raw materials are dried and ground, and then made into nodules with the addition of a relatively small amount of water. The nodules are then passed over a special preheating grate before entering the kiln. In the case of the Humboldt process, used at Plymstock, the powdered material from the mill is fed, as powder, to the kilns. In order to do this, it must first be passed through several stages of cyclones, where heat is transferred from the gases issuing from the kiln to the incoming powder, or " raw meal " as it is called. Electrostatic precipitation of the particles remaining in the spent flue gases is an essential final stage. In fact, recent improvements in this aspect of the process were, we understand, considered by the group to be a factor leading to its adoption at Plymstock.

The Plymstock kiln is oil-fired, but it is convenient to refer to fuel consumption in terms of coal equivalent. It was pointed out in our article on Cauldon works that about 25 tons of coal are consumed per 100 tons of cement produced in the " wet " process. This figure was expected to be 15 tons for Cauldon, and it has, in fact, been improved upon. For the Humboldt process at Plymstock the coal-equivalent is expected to be in the range of 12 to 13 tons. Fuel saving, as between the two processes, is not, therefore, important. The physical properties of the raw materials have, we understand, a bigger influence, for some materials granulate into nodules very easily, others with difficulty. Both processes have been developed in Germany, and in both cases German plant has been used.

Many of the features of Plymstock works —for instance the kiln itself, the kiln cooler, the bagging plant, and much of the instrumentation—show a general similarity to the Cauldon works. These aspects are referred to only briefly. The new works at Plymstock



1—Stone from weighfeeders.
2—Ball mill.
3—"Raw meal" air separator.
4—"Raw meal" cyclones.
5—"Raw meal" fan.
6—Electrostatic precipitators
7—Dust return.
8—"Raw meal" from weighfeeder.
9—Direct feed for starting up
I–IV—Four-stage cyclones of preheater.
10—Rotary kiln.
11—Drag chain Fuller grate cooler.
12—Oil fuel feed.
13—Precipitator fan.
14—Chimney, 200ft high.

Diagram of Humboldt preheater and "raw meal" grinding systems

replaces an adjoining works which has two shaft kilns. It lies to the south-east of Plymouth, on the east bank of the River Plym, about 2¼ miles from the city centre.

Raw Materials

Limestone and shale are quarried close to the works. The quarrying, crushing and screening plant follow normal practice. The sized materials are stored under cover. Materials are fed from storage to the grinding mill. At this stage all raw material has been reduced to 1in or less in size, and is classified into "high carbonate stone" and "low carbonate stone." Silica sand is also stored here, and can be added if needed. The rates of feeding the two main classes of stone are 20 to 80 tons per hour and 8 to 32 tons per hour respectively, the tonnage fed to the mill being recorded. Supply of raw materials from the store is controlled remotely from the mill control panel, which is in the Humboldt building.

The Humboldt Process

Grinding of the raw materials is linked with the next stage of manufacture, so it is now convenient to consider all the processes prior to the kiln itself. It is this group of operations which constitutes the process novel to this country, which is the speciality of Klockner-Humboldt-Deutz A.G. of Cologne. The plant for the operations (except for the blending and storage silos) was all supplied by that company to the Blue Circle Group. The diagram shows these stages in outline.

The mill is a single-compartment ball mill, the principal data for which are listed in the table. Stone is delivered to the mill by belt conveyor from the store to a large rotary feeder, which acts as an air seal. A chute leads from the feeder to the feed end of the mill. Hot gas from the preheater is drawn through the mill to dry out all moisture, and to carry away the fine particles produced by the mill. The gas stream goes from the mill to a separator. This device, which is 14ft 9in in diameter, separates out the particles which are too coarse (i.e. grit), a ı adjustment being possible to achieve the fineness of grinding required. A screw conveyor returns the grit to the mill.

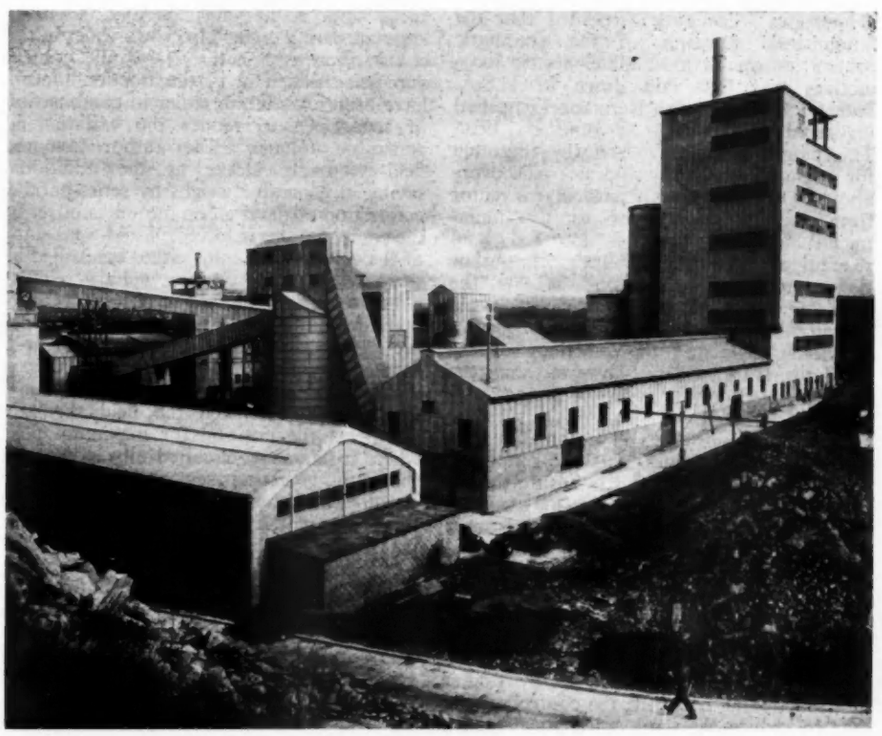
Next, the fine material is separated from the gas stream by a pair of cyclones. These cyclones are 10ft 4in in diameter and 25ft high. The gas is largely recirculated, just sufficient being added from the preheater to ensure that all moisture is removed from the "raw meal"; the spent cool gas passes to the electrostatic precipitators. The finally-ground solids are carried by air-slides to the raw meal blending and storage silos. The blending capacity here is about 1000 tons and the storage capacity about 3000 tons.

In each blending silo, the base is covered with ceramic tiles in cast iron boxes, attached to header pipes which "divide" it into four quadrants. A quadrant valve rotating at a given rate passes air at 15 lb per square inch to whichever quadrant of the base is being aerated. By-pass valves feed air at 5 lb per square inch to the other three quadrants, and as each one is blown in turn, considerable turbulence is set up within the raw meal and blending is achieved. The raw meal is extracted by air-slides into a central distribution box where final proportioning can be carried out. All the equipment here was supplied by Constantin (Engineers) Ltd.

As can be seen from the diagram, the hot gas circulation for the mill is bled off, and recirculated, from the main flow of gas exhausted from the kiln. The main stages of heat exchange—the Humboldt preheater—take place in the four-stage group of cyclones at the kiln exhaust. These cyclones, the mill and its associated separator and cyclones, and the electrostatic precipitators, are all situated in the Humboldt building, the 160ft tower, which can be seen in the illustration of the works herewith.

This process of reheating dry pulverised raw material was developed to utilise effectively the heat in rotary kiln waste gas. Powdered raw meal is fed continuously to the first stage cyclones, where it is suspended in the gas in the first "elevating" pipe, the upward flow of gas in this pipe immediately carrying the raw meal over into the first cyclone. Here it is precipitated, whence it drops by gravity into the next "elevating" pipe, and the process is repeated in the second and subsequent stages, until it is finally discharged into the kiln. Intimate contact

Data for grinding mill :	
Guaranteed output	55 t.p.h.
Corresponding fineness	12 per cent on 170 mesh
Size of feed...	—1in
Size of drum :	
Length	21ft 4in
Internal diameter	11ft 2in
Operating speed	17 r.p.m.
Steel grinding media :	
Total weight	67 tons
Sizes	3in–1in diameter
Power of driving motor for mill	1450 h.p.
Power of driving motor for mill fan	450 h.p.
Principal temperatures :	
Gas taken from preheater to mill	335 deg. Fah.
Gas at mill fan outlet	195 deg. Fah.
Raw meal entering preheater ...	128 deg. Fah.
Meal entering kiln	1500 deg. Fah.
Waste gas from preheater ...	700 deg. Fah.
Maximum kiln temperature ...	2600 deg. Fah.
Preheated temperature of fuel oil at kiln burners	230 deg. Fah.
Corresponding oil pressure ...	500 lb per square inch
Capacity of kiln cooler	700 tons per day to 150 deg. Fah



Plymstock works, showing top right, the Humboldt building with blending and storage silos immediately on its left, and the kiln building in front of it

between hot gas and meal provides the means of heat transfer. The raw meal enters the system at 128 deg. Fah. and is delivered to the kiln at 1500 deg. Fah. in a total process time of thirty seconds. The principal temperatures of the system are tabulated.

" Raw meal " is weighed before being fed to the preheater and there is an alternative method of feeding should the weigh feeder fail. Of the four stages of cyclones, the first comprises two cyclones in parallel, each 8ft 6in in diameter and 34ft 6in high ; the three subsequent stages each have one cyclone, 15ft in diameter and 35ft high. Fuel consumption in the kiln when this preheating system is used is claimed to be 1530 to 1620 B.Th.U. per pound of clinker, with recovery of 180 to 240 B.Th.U. for drying the raw material, giving a net consumption in the range 1290 to 1440 B.Th.U. per pound of clinker. Although the Plymstock plant is the first Humboldt plant in this country there are about seventy of them in use in other countries.

The electrostatic precipitators, which also form an essential element of the Humboldt plant, are two in number, each about 19ft wide by 26ft long and 23ft deep. There are four dust hoppers under each precipitator, and appropriate screw conveyors such that the dust can be returned to the raw meal storage hoppers.

The Kiln

The rotary kiln is of all-welded construction, 178ft long by 12ft 6in in diameter. It was made by Vickers-Armstrong (Engineers) Ltd. It is carried on three tyres ; the chairs for the tyres are riveted to the shell of the kiln, and the tangent plates carrying the driving gear are welded to the shell. The weight of the kiln, including refractory lining is 620 tons ; it is inclined at 3 in 1000, and rotates at 1·4 r.p.m. Its rated capacity is 600 tons of clinker a day. Oil is fed to the kiln through a stainless steel pipe (at temperature and pressure as listed in the table) with an atomising nozzle, with a by-pass to return any surplus. This equipment is housed inside a 7in jacketed pipe through which primary air is passed, and which in turn is protected by a 2in thick refractory coating. The burner is adjustable for position and direction and can be retracted.

Final Stages

The handling and grinding of the clinker from the kiln, addition of gypsum at the grinding stage, and then the storage and bagging of the cement, call for no special comment. A new silo of 2500 tons capacity has increased the total storage available to 7800 tons. Cement can be put in bags at a rate of 120 tons per hour. Road vehicles can also take cement in bulk.

Control of Diesel-Electric Locomotives

Methods are described for automatic adjustment of generator output to traction motor demands without overloading the diesel engine over the locomotive speed range.

A PAPER entitled " Control of Diesel-Electric Locomotives " was presented to the Institution of Locomotive Engineers in London on October 24 by Mr. O. Schlaepfer, Chief Traction Engineer, Sulzer Bros. Ltd., Winterthur. The author recalled that the fundamental principle of the automatic control system on most diesel-electric locomotives was first laid down in U.S.A. Patent 1,216,237, which Hermann Lemp had registered as far back as June 24, 1914. This patent had been practically forgotten for some fifteen years, and its rediscovery about 1930 prevented any particular inventor from claiming patent rights for the fundamental idea of governor-controlled load regulation. All makers using what the author designated " Lemp control " actuate the load regulator by an hydraulic or electric servomotor responsive to the engine governor. Methods used, and the functions of the regulator, vary widely, however, and the paper applied only to a few of many variations.

The main purpose of automatic load control is to correlate a definite output to each set engine speed, and to ensure that at the top notch the engine gives all available power without being overloaded. This must be effected over a wide locomotive speed range and independently of the temperature of the electrical machines and of the variable demands of the auxiliaries. If, however, the engine is unable to give its full power, either due to its having not yet reached normal service temperature, or due to a cylinder not functioning correctly, the control system has to reduce the load automatically by a corresponding amount.

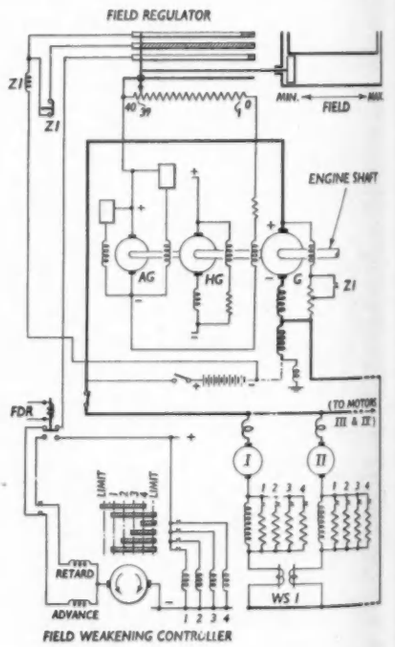
Ever since the first diesel-electric vehicle was built, the main generator feeding the traction motors has produced a varying voltage. This is one of the drawbacks of electric transmission, since the size of the generator is a function of continuous current and maximum voltage. As the vehicular speed range within which the load has to be kept constant has steadily grown wider in the course of development, series-parallel control and field-weakening of the traction motors have been introduced, either in combination or separately, to reduce the variation in generator voltage. The author favoured field-weakening alone, as the additional saving in generator weight by series-parallel connection of the traction motors is offset by the complications involved. Field-weakening of the traction motors is either controlled by the load regulator or by a voltage relay.

Proceeding to discuss a particular automatic regulating system, the author described the regulator-controlled traction motor field-weakening used in certain British Railways diesel-electric locomotives of Types 2 and 3 (see diagram). When the field regulator arrives at the position for maximum field, where it has short-circuited all resistance in the main generator separately-excited field circuit, it switches in the " advance " coil of the motor of the field weakening controller, provided that the field divert relay (*FDR*), which is operated by main generator voltage, is lifted. The field weakening controller, at its position 1, switches in the field weakening contactor 1 of every traction motor circuit. The corresponding overload will cause the generator field regulator to switch in resistance again so that the field weakening controller does not advance any further. If the train further accelerates, the regulator returns to position zero, so that the " advance " coil of the field weakening motor is again energised. Thus the field weakening controller is moved in steps to position 4, until the limit switch opens the circuit of the " advance coil."

When the field divert relay drops because of decreasing voltage, due to deceleration of the train, the " retard " coil of the field weakening motor is energised, and the field weakening controller moves one notch back towards position 1. Due to the corresponding unloading, the load regulator will establish stronger generator field again so that *FDR* is again lifted, thus preventing the " retard " winding of the field weakening motor from notching back more than one step. When the driver's controller is brought back from full power to idling, the field weakening controller automatically goes from position 4 to 0 (full field).

When the generator field regulator has advanced to its position 1 (i.e. while one resistance step is still in circuit), contactor *Z1* closes and shorts out resistance in the main generator self-excited field. This contactor is held closed through a holding contact until the field regulator has returned to contact 40 (minimum separately-excited field). It then opens and further reduces the regulated output by introducing shunt field resistance. This feature, found in British Railways Type 2 and Type 3 locomotives with Crompton Parkinson electrical equipment, provides a further safeguard against overloading in circumstances such as a failure of one cylinder in the diesel engine.

After dealing with the load characteristics of traction generators with various forms of excitation, some enabling load regulators to be dispensed with in shunting locomotives, the author said he believed Brown Boveri had first conceived the idea of " mixed " excitation with separately-excited, shunt, and reverse-compound field windings. This system has the advantage of reducing the operational range of the load regulator because of the drooping characteristic of the generator, besides having an automatic limiting effect on the maximum current. The load regulator can then effect maximum excitation when the locomotive is starting a



G—Main generator.
HG—Heating generator.
AG—Auxiliary generator.
Z1—Contactor in shunt field of main generator.
WS1—Wheel slip relay.

Automatic regulating system including load regulator controlled traction motor field weakening as used on certain B.R. locomotives of Types " 2 " and " 3 "

train, without risk of tripping the overload relays. However, development of means for avoiding "hunting" of the governor-controlled load regulator favours starting with it in the minimum field position and using its first few steps as starting notches. This has the advantage over contactor-controlled starting steps that fewer control lines are needed for multiple-unit working. Speed of notching up can be controlled closely to any desired degree.

In some British Railways locomotives of Types 2, 3 and 4, the driver's controller has certain starting positions in which very low outputs are obtained by making the output characteristic steeper below the normal regulation range, a double-fulcrum lever system being used between the fuel rack and the load regulator slide valve. Load regulators and governors are often designed to allow alternative minimum or maximum excitation for starting.

Use may be made of such additional excitation steps in anti-slip control. A solenoid incorporated in the governor may be arranged to operate the slide valve of the load regulator in order to reduce excitation until slipping ceases, going down to the special minimum condition if necessary. This action may be initiated automatically by slip-detecting relays, or else by the driver operating a push-button, this action being, possibly, combined with application of the anti-slip brake. The solenoid may also act as a current limiting device, either for starting with a limit lower than that inherent in the generator characteristic, or for imposing a limit where this condition does not obtain.

Various tests were then described by the author in which several aspects of a locomotive control system have been studied in operation by means of a Honeywell "Visicorder" light beam recording oscilloscope. It has been found that by this method a few seconds of running time produce material for one or two weeks of analysis by a two-man evaluation team.

The paper proceeded to describe a static excitation system used by the General Electric Company of America in which the control is derived from the engine governor, but excitation is taken from a three-phase alternator *via* transductors and rectifiers. Several d.c. signals may be fed to a transductor control winding so that their sum causes saturation of the core, and the one which will determine the a.c. will be the one which has reached its limit at a given moment. By suitable connection of the transductors and rectifiers, the excitation current follows its control signals in the sense of their importance. Another scheme proposed by the same company uses semiconductor devices. Here excitation for the traction generator exciter is controlled by a power transistor under the influence of variable-width pulses produced by a transistor oscillator. The pulse width is determined by signals from reactors having their control windings in the d.c. traction circuit (as well as from other sources, including the load regulator). These are compared with a reference derived from a zener diode/rectifier function generator circuit, and any error is applied to the pulse width modulator of the oscillator.

The author discussed methods of engine speed control and said that even where this was continuous, there were advantages in defining notches on the controller itself. This tended to restrain the driver from moving too fast from idling to full load, and led him to use intermediate positions rather than oscillate continuously between the extremes. Even as a basis for reports on locomotive performance, he considered, such notches are quite useful. Sometimes a controller has positions only for notching up or notching back automatically (possibly with alternative settings giving a fast or slow rate), but he thought drivers preferred to know the actual control position on which they were running at any moment. However, the system economises in the number of control wires needed and is in keeping with the present trend. Another step in this direction has been the transmission of control signals as high-frequency impulses over a train heating cable, as developed by Brown Boveri and used for remote control of a "V100" class locomotive of the German Federal Railway. It would be a very small step to dispense with the heating line and use wireless transmission for control signals between two locomotives on a train, or between them and a separate control car. While such equipment is not very cheap, it might be an economic alternative to equipping the whole passsnger and freight rolling stock of a railway with control wires.

Transistorised Radiotelephone

FOR use in overseas territories where power supplies and public communications facilities are limited, a robustly constructed equipment for telephony and c.w. telegraphy in the h.f. band has been introduced by Pye Telecommunications Ltd., Newmarket Road, Cambridge. This is known as the "Mercury" radiotelephone, and consists of a 20W transmitter and a receiver on separate chassis housed in a single cabinet as illustrated in Fig. 1. Eight pre-set transmitting

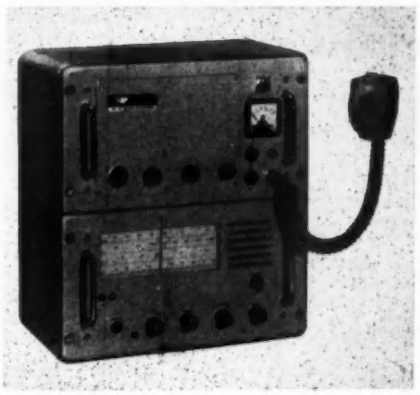


Fig. 1—Low-consumption h.f. transmitter/receiver equipment

frequencies can be selected, normally four each in the 1·6 to 3·8 Mc/s and 3·8 to 10 Mc/s bands; the receiver is continuously tunable over both these ranges and also from 535 to 1605 kc/s in the broadcast band. The equipment is supplied for 12V or 24V. Typical current consumptions on r/t transmission with average modulation are 8A and 5A respectively at these voltages.

The fully-transistorised receiver is a superheterodyne with one r.f. stage, separate oscillator and mixer circuits, two i.f. stages, a diode detector, and three a.f. stages, the first of which serves also as an a.g.c. amplifier. Input limiting is provided for the r.f. stage by a diode connected between the aerial and earth, and in the second a.f. stage output a diode noise limiter reduces pulse interference such as that caused by vehicle ignition systems. A beat-frequency oscillator injects a 470 kc/s signal into the base circuit of the second i.f. amplifier for c.w. reception. Receiver l.t. is taken from a filter unit at the back of the cabinet, which also supplies l.t. to the transmitter. The receiver has an independent on/off switch so that current drain is reduced when transmission is not required. When the transmitter is used in conjunction with the receiver, the transmitter switch is turned "on" to establish the supply to both units, but the receiver is de-energised when the Morse key is down or the microphone pressel switch is operated. To allow accurate back tuning of the receiver to the transmitter frequency, however, a "net" switch on the receiver is pressed to maintain the receiver supply when the transmitter send/receive relay is in the "send" position. With the Morse key "up," the receiver is operative for "listen through" purposes, and the same applies when the microphone pressel switch is released.

Transistors are used in the transmitter in the d.c./a.c. converter for the h.t. supply, and in all the modulator stages. For h.t. purposes two transistors in a saturable core switching circuit supply a.c. through a transformer to a diode bridge rectifier. The modulator consists of two a.f. amplifiers (the first incorporating pre-set gain control), an a.f. impedance matching stage, and a push-pull output stage transformer-coupled to the anodes and screens of the transmitter r.f. amplifier valves. The transmitter itself consists of a pentode crystal oscillator with eight-channel switching, coupled to a power amplifier formed by two beam tetrode valves in parallel. A multi-wafer channel-selector switch selects simultaneously the required crystal and the appropriate tap on the aerial tuning inductance. Final adjustment is made by means of a variable capacitor with the help of a meter which is used also for checking transmitter power supplies, drive, power amplifier current, modulation, and received signal strength, according to the position of a selector switch.

Keying for c.w. transmission takes place in the cathode circuit of the oscillator, one contact of the send/receive relay being arranged to short-circuit a cathode bias resistor when the key is pressed. Keying speed is 25 bauds. The same contact is held closed by operation of the microphone switch. Two other contacts on this relay connect the supplies to the transmitter or receiver as appropriate, and earth the transmitter aerial when the Morse key is "up" or the microphone switched off. A separate relay changes over the aerial connection between transmitter and receiver, and during transmission short-circuits the receiver aerial socket to the outer braid of the receiver aerial-connecting cable. Modulator l.t. is switched off by means of a c.w./r.t. switch when Morse is being transmitted, and a second wafer of the same switch by-passes the secondary of the modulation transformer in the h.t. feed to the transmitter power amplifier.

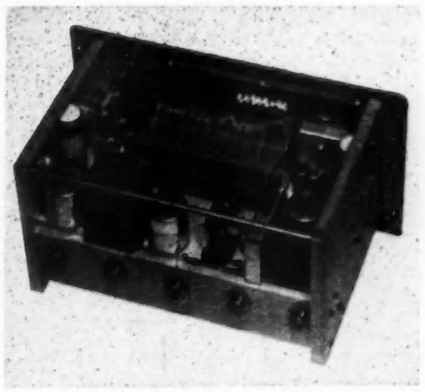


Fig. 2—Transmitter chassis, showing its use as a heat sink for the five power transistors in the modulator and h.t. converter circuits

The transmitter chassis is shown in Fig. 2, where the arrangement of the five power transistors on a heat sink will be noted. These are the driver and output transistors of the modulator, and the two transistors of the d.c./a.c. converter. The metal cases of the transistors are at collector potential, and are insulated from the heat sink by porcelain washers which are coated on both sides with silicon compound for good thermal contact.

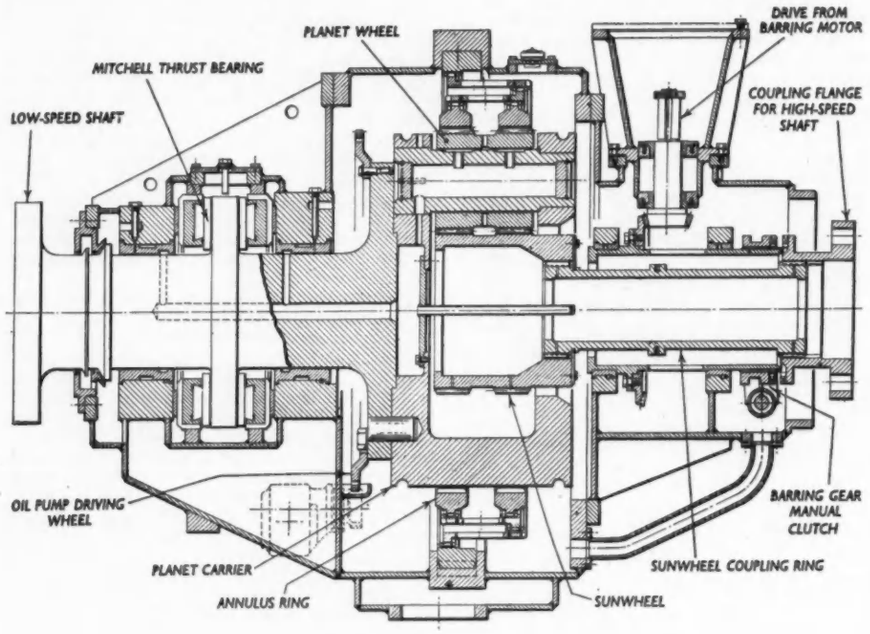
[Reply Card No. 1324]

Marine Epicyclic Gears

AN important part of the activities of W. H. Allen Sons and Co. Ltd. for a number of years has been the design, development and production of Allen-Stoeckicht epicyclic gears. Early work was carried out at Bedford, but owing to increasing volume of production and the lack of both space and skilled craftsmen, manufacture has been transferred to the company's Atlas Works at Pershore which have been equipped with modern machinery for the cutting of gears. Several factors have contributed to the increasing application of epicyclic gears to industrial and marine drives, including the adoption of a floating, flexible annulus to ensure that the planet wheels share the load equally. Improvements in precision gear cutting machinery and techniques have also resulted in the production of internal gears to the same degree of accuracy as external gears. To-day the original spur or single-helical epicyclic gears have been replaced by double helical designs to provide a highly developed unit as standard practice.

Apart from industrial applications, there has been important work done in the marine field, particularly for naval craft. For merchant ships the latest use of the gear is the double reduction gearing fitted in M.V. "Bass Trader" which transmits 2200 h.p. from a "Deltic" turbo-blown diesel engine and gives a speed reduction from 1630 to 180 r.p.m. Recently completed at the Atlas Works are gears forming part of the scheme to convert two Liberty Ships from steam to diesel propulsion. The ships concerned, which are presently named "Sein" and "Auray" and will be renamed "Pan" and "Velos" on conversion, are owned by Zim Israel Navigation Co. Ltd. and are being converted by the Ateliers et Chantiers de Bretagne at its shipyard at Nantes. Both ships are of 12,000 tons displacement and will have an A.C.B./Pielstick reversible twelve cylinder diesel engine of 4200 h.p. installed. This will drive the propeller through a fluid coupling and an epicyclic gear, to the slow speed shaft of which the propeller shaft will be solidly bolted.

This gear has been designed on a long-life basis, essential for marine installations, and has been built to meet the requirements of Bureau Veritas but would also conform with the rules of Lloyd's Register. Our line drawing shows a section through the gear, which is of planetary design and in which the annulus system is held stationary so that both the input and output shafts have the same direction of rotation. The sunwheel is connected to the fluid coupling by a double toothed flexible sunwheel coupling ring, the input flange of which is carried by the fluid coupling. There are six planet wheels which are driven by the floating sunwheel. The annulus system is flexibly coupled to the gear case and the drive is transmitted through the planet wheels to the rotating planet carrier which is bolted to the output shaft. A Michell thrust bearing is incorporated in the casing and takes up the propeller thrust of 50 tons transmitted by a forged collar on the output shaft. At the input end there is provision for turning gear; a small geared motor drives through a pair of straight bevel gears and a manually operated dog clutch which engages with the input coupling flange to give a turning speed of about ½ r.p.m. As assembled the Allen-Stoeckicht gear has the following overall dimensions; 106⅞in length between input and output flanges, 37⅞in below shaft centre line, 33⅞in above shaft centre line, and a width of 35½in in each side of the shaft central line, figures which illustrate the compactness of the gear. The weight is approximately 10 tons compared with the 28 tons of an unhardened parallel shaft gear of equivalent duty and 21 tons of a hardened parallel shaft gear.



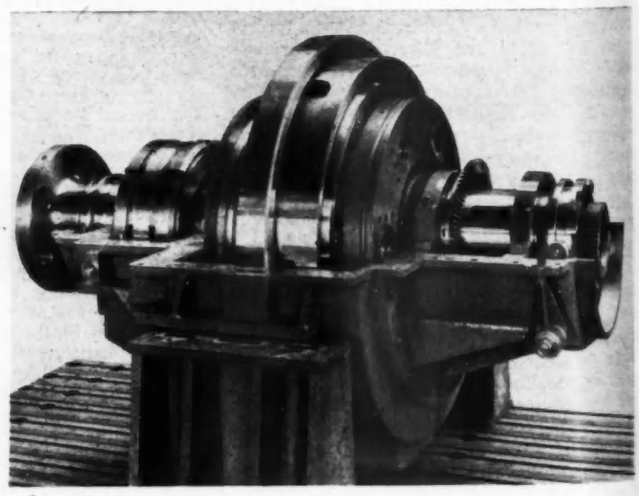
Section through the gear

The gears have a 30 deg. helix angle, and the sunwheel and planet wheels of "Nitralloy" are hardened by the nitriding process which requires no quenching and leaves a clean tooth surface for which grinding is unnecessary. The annulus ring, of carbon steel, is fully heat treated and the planet wheel spindles are faced with white metal to form a bearing about which the wheel rotates. This arrangement ensures that the load on the white metal bearing is unidirectional so that there is reduced chance of failure through fatigue. Furthermore this dispensing with a bush enables the bore of the planet wheel to be completed before the teeth are finished so that they are true with the bore.

For lubrication purposes there are two pumps driven off a wheel mounted on the low-speed shaft and these pumps are automatically reversible by means of a system of non-return valves. The lubrication system includes coolers and filters: the oil, which should be good quality mineral oil, is piped from the cooler to the low-speed bearings and then passes by means of an annular groove and radial holes to the centre of the output shaft and is then distributed to the planet wheel spindles and gear teeth through various drillings. For starting up and below quarter speed a motor-driven pump is employed and this cuts out automatically when the mechanically driven pumps have attained the operating pressure of 30 lb per square inch. The mechanically driven pumps each have a capacity of 50 gallons per minute and are capable of giving full output down to quarter speed. The acceptable inlet temperature of the lubricating oil is about 110 deg. Fah. and the rise in temperature across the box at full speed and full load is approximately 15 deg. Fah.

Maintenance of the gear, of which we include an illustration with the gear case top cover removed, is straightforward: after removing the upper part of the horizontally split casing, the plates locating the sunwheel coupling ring to the sunwheel are removed. Then the sunwheel coupling ring is slid out of engagement with the sunwheel. Next the low-speed shaft is disconnected from the planet carrier and the latter jacked off the spigot on the low-speed shaft. Special slings are provided to remove the planet carrier assembly complete with the annulus system and the assembly is turned through 90 deg. and laid on the input face of the carrier. Then the removal of the large spring rings enables couplings and annulus rings to be dismantled.

The gear, which we have seen demonstrated, although designed to transmit 4200 h.p. is conservatively rated and at 418 r.p.m. input speed and 128 r.p.m. output speed could transmit up to 6000 s.h.p. The accuracy of manufacture of components renders the gear suitable for operation at higher speed and it is claimed that at a typical naval propeller shaft speed of 350 r.p.m. the gear could transmit 23,000 h.p., while at the maximum output shaft speed of the gear, 600 r.p.m., 40,000 h.p. could be transmitted. The power to run the demonstration gear was 20 h.p. which indicated a load efficiency of about 99 per cent.



View of gear with gear-case top cover removed

SHORTER REPORTS

120MW Thermal-Electric Generating Set Planned at Dundee

THE North of Scotland Hydro-Electric Board has applied for the Secretary of State for Scotland's consent to extend the Carolina Port steam power station at Dundee, and to bring forward to 1965 the commissioning there of the 120MW steam generating set included in the programme for 1966. A further addition is planned to follow within a few years. The new plant is planned for oil-firing.

The Board states that " this increased capacity is needed to meet the growing demand of the Board's consumers, and will restore to a suitable level the proportion of thermal to hydro-electric generation. It will enable the Board to continue to make the best use of these two sources of power in serving its own area and meeting its commitments to the South of Scotland Electricity Board." The present generating capacity of the Dundee power station is 75,625kW. The last extension was commissioned in 1957 when a 30MW generating set replaced 18MW of old plant. The consulting engineers for the work are Messrs. Strain and Robertson.

Research Centre for Rope Technology

A WEEK ago to-day a new research laboratory was opened at Doncaster by Mr. Niall Macpherson, the Parliamentary Secretary to the Board of Trade. The laboratory has been built and equipped by British Ropes Ltd. on that company's premises, at a cost of nearly £200,000. The Central Research Department of the company is organised into a wire division and a rope division, which are now served, it is considered, by research facilities unrivalled in the industry.

In the wire department investigations range from raw material testing, through heat treatment and wire drawing, to the final product. The quality of hard drawn wire is governed to some extent by the quality of the raw material—wire rods. The department is making an extensive study of the characteristics of its regular supplies of rods, particular attention being devoted to the number and type of surface defects. This is long term work, but work which, it is hoped, will result in an improvement of quality of the raw material.

While the metallurgy of plain carbon steels is fairly simple, the continuous nature of the heat treatment process used in wire production is considerably more complex than the heat treatment of individual components. Therefore, a special recording pyrometer has been developed to reveal temperature changes in material as it proceeds through the plant. With this and supplementary work in the laboratory evidence has been produced, it is believed, which has enabled considerable improvements to be made.

Apart from finished wire quality, the precise physical characteristics of various types of wire are of great importance, and much of the department's time is spent on the determination of, for example, fatigue strength, stress relaxation and stress/strain factors. Haigh-Robertson rotating bending machines and an Amsler "Vibrophone" push-pull machine are in constant use for fatigue testing. An air-conditioned room houses the equipment used for determining the stress relaxation properties of prestressed concrete wire ; apparatus is available for the testing of both individual wires and strand.

Complete metallurgical examinations of wire, both before and after service, are made from time to time. In a typical examination each wire is taken from a length of a multi-strand rope and examined for physical properties, metallographic structure and chemical analysis. In addition to the apparatus already mentioned the department has a range of physical testing equipment, including bending and torsion testing machines and numerous tensile testing machines. Among the latter is an Instron machine which is based on the strain gauge cell weighing system.

As the production of high tensile steel wires becomes more developed, the internal microstructure of the metal increases in importance. The limits of discernment of the light microscope have been reached and it is considered that only by the use of the electron microscope can further advances in the technology of wire production be made. Accordingly an Elmiskop II electron microscope manufactured by Siemens and Halske of Karlsruhe in Germany has been installed. It can resolve details one-tenth of a millionth of 1in apart, and the maximum useful magnification is about 50,000.

The rope department of the central research department is divided into six sections, namely : (*a*) chemical analysis ; (*b*) metallurgical examinations ; (*c*) physical testing ; (*d*) fibre and synthetics evaluation ; (*e*) photographic documentation ; (*f*) development. Their work includes the following subjects.

General chemical and metallurgical analyses are carried out, with laboratory studies of rope lubricants and dressings, plus studies of corrosion and its prevention. Preparation and examination of samples from the company's marine testing station off the Norfolk coast are also undertaken. The metallurgical section works closely with the physical testing section on the metallurgical aspects of fatigues in ropes, and with the chemical analysis section on corrosion. It also undertakes specific research projects such as a study of the factors which influence the stress corrosion of high tensile copper-nickel wire. Physical testing includes tests of wires, strands and ropes for characteristics such as ultimate tensile strength up to 100 tons load, modulus of elasticity, &c., pulsatory and reverse bend fatigue tests, and the evaluation of lubricants. The chemical and physical evaluation of rope cores, with special reference to synthetic materials, laboratory and field tests of microbial agents and rot-proofing are all responsibilities of the fibre and synthetics section.

Equipment of the rope research department includes a Zeiss photo-micrographic unit, capable of examining specimens by transmitted or reflected light at magnifications up to 4400 ; a 100-ton capacity Amsler Universal pulsatory fatigue testing machine, capable of applying static and dynamic loads to ropes of up to 2½in diameter ; a Watson stereoscope microscope with camera attachments ; and a Denison 15-ton capacity hydraulically operated tensile machine.

Tamar Bridge Opened to Traffic

THE accompanying illustration is a recent view of the Tamar suspension bridge which now forms a road link between Devon and Cornwall beside Brunel's famous railway bridge. The new Tamar bridge was opened to traffic on October 24, but only two lanes (eventually there will be three) are in use, and the bridge is not yet finished and will have its official opening next Spring. As can be seen, the catwalks are still in position and so are the cranes at the towers. Cable wrapping has still to be carried out, amongst other tasks. The bridge has been built as a toll bridge, and there was evidently a desire to gather revenue as early as possible.

The main span of the bridge is 1100ft, and the two side spans are each 374ft long. A departure from established practice lies in the use of locked-coil wire rope for the main cables, there being thirty-one ropes in each cable.

The Tamar bridge has been built for the Tamar Road Bridge Joint Committee, at a cost of about £1,750,000. The consulting engineers for the bridge are Messrs. Mott, Hay and Anderson, and the main contractor is the Cleveland Bridge and Engineering Company Ltd.

The Tamar suspension bridge. The catwalk and constructional cranes on the towers are still in position. Note the toll booths, and, on the left, Brunel's Royal Albert railway bridge

SHORTER REPORTS *(Continued)*

Recording range, height and bearing of a meteorological balloon while it is tracked by radar

Windfinding by Radar

A DEMONSTRATION was given last week by Cossor Radar and Electronics Ltd., The Pinnacles, Harlow, Essex, of the use of the Cossor C.R. 353 meteorological radar for windfinding. In this function the C.R. 353 equipment (described in THE ENGINEER of February 3, 1961, p. 180) is used to detect and track a passive reflector carried by a free balloon, thereby making it possible to compute wind velocity at all heights up to the bursting point of the balloon.

When the balloon is released, it is first sighted by a manually-operated optical device at the release point. Subsequently it can be tracked manually by means of controls on the right-hand console in the accompanying illustration, or automatically by the equipment. The three-positional co-ordinates of the reflector are displayed on visual indicators on the data presentation unit in the foreground of the illustration. Bearing and elevation indications are at intervals of 0·05 deg. The range indicator displays the range as a six-figure read-out correct to the nearest 25m. Maximum slant range in the windfinding role is 250km (120 n.m.). A timing device incorporated in the display arrangement provides pulses which freeze all the indicators at regular intervals so that the co-ordinates of the target, at the instant of each pulse, can be easily plotted.

Optional additions to the data presentation unit can include an automatic print-out unit for recording positional information, and a computer to covert the slant range and elevation co-ordinates into ground range and height co-ordinates. The second operator in the illustration is watching the signal in the range gate. This is desirable in case the signal is lost when it becomes very weak, for the operator can then go over to manual tracking while his colleague continues to record data. Manual control may also be needed when the target is at low altitudes and subject to the effects of ground clutter. For the initial operations of putting the radar on target it is convenient to have two operators, although the addition of print-out equipment to the display unit makes it feasible for one operator to do the work if necessary.

In its application as a weather radar, the equipment is used to observe the position of storm centres and to assess densities of clouds and rain precipitation. The radar echoes are displayed on a 12in plan position indicator. This unit incorporates iso-echo circuits which enable the operator to make cloud density determinations. Cloud heights can be estimated by varying the vertical tilt of the aerial.

Maximum range of the C.R. 353 as a weather radar is principally determined by the curvature of the earth and in practice is about 200 n.m. Intermediate switched range scales of 100, 50 and 25 n.m. are provided. The displayed p.p.i. information can be remoted by cable or radio link and, if required, arrangements can be made for remote operation of the equipment. The unit demonstrated was one of eight which are to be delivered shortly to the New Zealand mainland, Fiji, Raratonga, and Funafuti.

[Reply Card No. 1327]

Engine and Equipment Manufacture

IN the last few years there have been radical changes in the product policy of Bristol Siddeley Engines Ltd., the firm formed by the combination of Bristol Aero Engines Ltd. and Armstrong-Siddeley Motors. Neither cars nor automotive engines are built by the present company, Bristol Cars Ltd. having been sold to a new owner, and the company no longer makes small piston engines, this activity having been transferred to Petters Ltd., a subsidiary of one of the parent firms, Hawker Siddeley Ltd. Instead of liquid oxygen rockets the firm now builds hydrogen peroxide motors, while air-breathing aircraft engines in production are solely of turbine or ramjet design ; the former have relatively numerous applications and some of the engines are built in two or three forms.

The place of the petrol engines has been taken by diesel engines of Maybach design built under licence, and a licence has also been obtained to manufacture transmission equipment to the designs of Svenska Rotor Maschinen (S.R.M.). A new activity is the manufacture of gas-lubricated hydrodynamic bearings for use particularly in the gas circulators of nuclear power plant.

Many of both the past and present products will be familiar to our readers, particularly perhaps, the " Proteus " gas turbine which has found applications on land, on sea, and in the air. The much larger " Olympus," which has been developed as a pure jet engine, is being adapted to provide shaft power by the addition of a third turbine ; to avoid developing a costly gearbox to handle the extremely high power involved, the new turbine is designed to run at 3000 r.p.m. and hence dwarfs its gas generator. Each " Industrial Olympus " will be capable of driving a 15MW generator, but applications are also seen in vehicles of high power-weight ratio which are too slow to employ the basic " Olympus," e.g. hydrofoil boats and ground effect machines. Possibly less familiar are the S.R.M. transmissions, which are applicable to road and rail traction and other duties in which output speeds and loads vary widely. The transmission is a converter-coupling with a two-stage turbine, which can be embellished with either or both of two means of altering the mode of operation. The simplest is a direct drive clutch uniting the turbine with the impeller. The other is an epicyclic cluster with two band brakes, one of which holds the reaction member stationary as in the normal converter and the other forces it to run at a high speed in the direction opposite to the turbine ; the latter selection corresponds to high torque multiplication (e.g. 9·6 instead of 4·2 at stall) with the turbine free or to hydro-kinetic braking with the turbine locked to the impeller. Changes between modes, other than the selection of braking, are made by an " auto-pilot " which senses both speed and impeller/turbine speed ratio. Further optional additions are a reversing train, which if required can furnish a forward reduction, and, for the smallest converter with capacities of 90 h.p. to 200 h.p., a " V " drive turning the output through an obtuse angle to suit vehicles with the engine mounted transversely. Other S.R.M. components are hydrostatic clutches and brakes, each consisting of sets of pinions meshing to form a gear pump ; in the case of the clutch, closing off the pump delivery forces the pump housing to rotate instead of the gears running within the pump, while in the case of the brake the oil is forced through a relief valve and returns to the input through a heat exchanger. In both these applications the pump efficiency is clearly unimportant, so that these components do not afford an approach to a hydrostatic transmission.

Gas-bearing circulator being assembled in conditioned air filtered to 3 microns

The gas bearing circulators are, to meet the customers' requirements for use in radioactive environments, assembled in " clean " conditions. A suite of rooms has been built at Anstey aerodrome by John Bass Ltd. to afford this facility ; it comprises a " semi-clean " room with heating and air-filtration to 5 microns, a fully clean room with air conditioned to 68 $\pm\frac{1}{2}$ deg. Fah, 30 per cent relative humidity, and filtration to 1 micron, and two final build cells with conditioned air and filtration to 3 microns. The suite is built from timber and hardboard and lined with a " cocoon " of welded P.V.C., and the light fittings are on the outside. The heating and refrigerating plant is also used to control within ± 2 deg. the temperature of the room housing the Springfield vertical grinder and the Vernon measuring machines employed to checking the accuracy of bearing surfaces.

Capacitor Bank for Testing Transformers

A LARGE bank of capacitors for increasing the MVA capacity required for proving tests on power transformers has been designed, manufactured and installed at the Hollinwood works of Ferranti Ltd. by British Insulated Callender's Cables Ltd. The fact that an existing synchronous condenser was available on the site and could be used as an alternator at 60 c/s influenced the choice of a capacitor installation as the quickest and most economical means of obtaining a larger test supply. By using this synchronous condenser in conjunction with the capacitor bank it will be possible to test very large transformers, such as the 400MVA, 380/275kV, three-phase, auto-transformer recently ordered by the Central Electricity Generating Board.

The capacitor bank (illustrated below) is connected to the secondary winding of a new 15MVA test transformer and has two electrically-identical 33·6MVAr sections which are connected in parallel to give the total available output of 67·2MVAr at 60 c/s. In this outdoor installation the capacitor bank can be energised either from the new 15MVA transformer, which is adjacent, or from an older transformer inside the transformer production building. It is the largest industrial installation of power capacitors in Great Britain. The bank consists of 2688 units of 336 racks and is connected to the transformer test area by twin overhead line plain aluminium conductors. It is served by incoming busbars rated to carry 3000A root mean square continuously. Both the conductor and the busbar systems were designed, manufactured and installed by the B.I.C.C. Group.

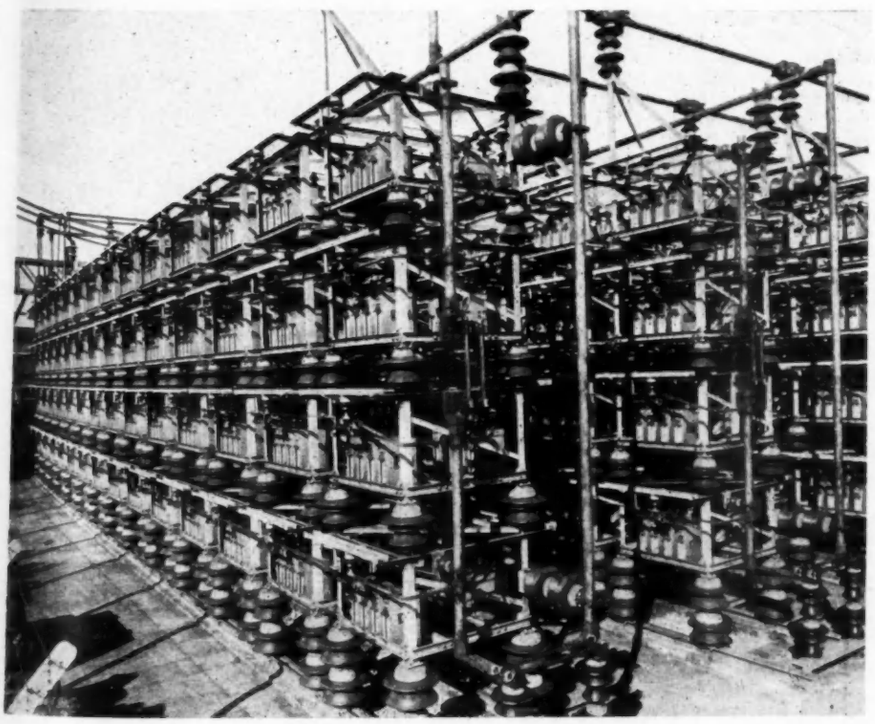
The overhead conductor system is terminated by a gantry inside the transformer production building. Two off-load isolating switches are mounted on the gantry and these are used : (1) to connect the test transformer and capacitor bank to the transformer under test ; and (2) to short circuit and earth the capacitor bank terminals after isolation from the supply, on completion of a test.

For some tests the capacitor bank must be connected in star with the neutral point floating. Because of this an additional isolating switch is provided on the main outdoor switch gantry and this permits the floating neutral point to be connected to earth before anyone can enter the capacitor compound. After entering the capacitor compound on completion of a test, the standard procedure is to close all isolating switches using insulated operating poles. Thus each rack is individually short circuited.

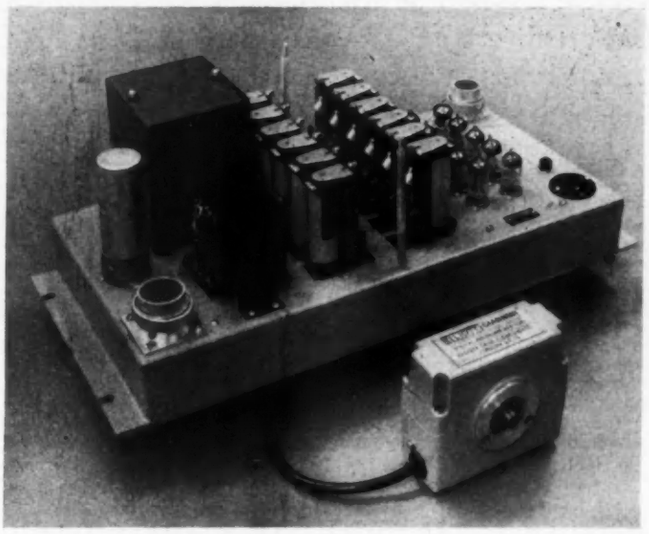
Connection of the capacitor bank to the secondary side of the test transformer enables a comparatively small transformer and associated regulator to be used for testing very large transformers up to 400MVA rating. This form of connection has the additional advantage that once the bank has been set up for testing a given transformer no change in setting is required for alternative tests which are sometimes necessary at different ratings.

The use of the capacitor bank in association with the 6MVAr synchronous condenser and the 15MVA test transformer provides for the supply of a test load of up to 70MVA, without exceeding 8MVA from the North Western Electricity Board. The capacitor installation is inherently flexible in terms of voltage and kVAr settings, which is very desirable, because the reactive kVA needed for a test varies even for transformers of the same rating. It is possible to set up the bank for a test in 15 minutes.

[Reply Card No. 1336]



Bank of capacitators rated at 67·2 MVAr, 66kV, for proving tests on power transformers



Encoder and electric converter for digital presentation of analogue information

Analogue-Digital Conversion Equipment

THREE main applications are covered by the range of "Datex" analogue-digital converters and associated units. which can now be supplied by Elliott Brothers (London), Ltd., a member of the Elliott Automation Group, 34, Portland Place, London, W.1. Some of these are already in production under an exclusive licence from Giannini Ltd., the British affiliate of the Datex Corporation, Monrovia, U.S.A.

Two of the applications are to data acquisition and reduction (such as digitising voltages or currents to measure physical variables), and to measuring position co-ordinates for navigation. The third covers the measurement of position co-ordinates for machine control. A convertor consists of an encoder and a decoder. The encoder, one form of which is illustrated, is a rotary commutator which converts angular position into digital electrical signals. This coded output is converted by electro-mechanical or electronic apparatus into a suitable form for display, recording or further processing. The output normally takes the form of a digital (decimal) lamp-bank display, printed records, paper tape, or punched cards. Systems of this kind can be used to control the amount of shaft rotation required in a machine tool ; to provide a running digital indication of the position of a carriage or slide driven by a lead screw, and to measure and record the lengths into which steel pipes, sheets or bars are cut in a steel mill.

[Reply Card No. 1328]

N.A.T.O. Radio Station for the Northumberland Coast

THE Government has upheld a proposal by the Air Ministry to build a radio station at Newton Point, near Alnwick, Northumberland, as part of a N.A.T.O. navigation system. It will consist of a slender aluminium mast 130ft high, a 67ft timber pole, technical and domestic buildings and a stand-by power house.

The station will be the centre one of a chain of three to provide a dependable means of fixing the position of ships and low-flying aircraft. Since the end stations of the chain have to be as far apart as possible, and there must be a clear over-sea path between adjacent stations, location of the central station was limited to certain points on the Northumberland coast between Hauxley in the south and Seahouses (North Sunderland) in the north. An extensive survey of possible sites within this area was undertaken.

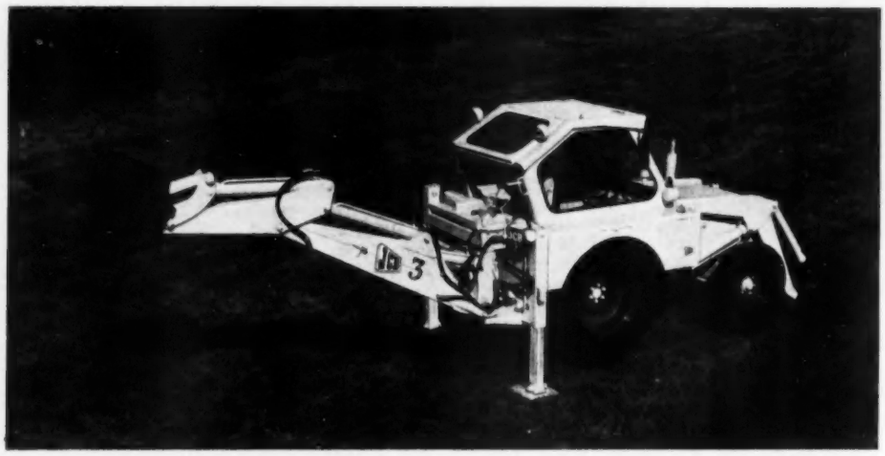
The contours of the site which has been chosen offer opportunities for the buildings to be partially concealed from many points of view, and the main buildings have been carefully sited to take advantage of this possibility.

SHORTER REPORTS *(Continued)*

Hydraulic Excavator

A NEW hydraulic excavator has been introduced by J. C. Bamford (Excavators) Ltd., Lakeside, Rochester, Staffs, to provide medium and small building concerns and contractors with an economic machine for offset trenching, ditch cleaning, site preparation and loading duties. This machine, known as the "J.C.B. 3," is a smaller version of the firm's "J.C.B. 4" and it incorporates a number of improvements to impart the high degree of versatility, manoeuvrability and ease of operation required on smaller sites.

The general design of the excavator can be seen in the illustration on this page. In addition to normal back acting operation in trenching work, the excavator can be used as a face shovel. A point of particular interest in the design is the carriage mounting of the digging arm king post assembly on a transverse guide structure which runs across the full width of the machine and forms an integral part of the main frame. By loosening four nuts on the king post carriage the complete post with the arm can be moved to any required station across the front of the machine to enable it to work close to walls and fixed structures.



Hydraulic excavator raised on stabilisers with loader bucket ready to commence a trenching operation

The excavator arm exerts a tearout force of 11,600 lb and it can be fitted with shovels from 15in to 33in wide, all of which can be supplied with side cutters ; also available are an 8in to 12in taper clay bucket, a 36in square hole digging bucket, and a 60in ditch cleaning blade. The arm has a standard reach of 15ft 7in and it gives a maximum digging depth of 13ft, with a loading height of 9ft 4in when operating as a back acter or 10ft 9in when operating as a face shovel. This arm has a slewing and digging arc of 200 deg. The front end loader equipment includes a ½ cubic yard, 46in wide bucket ; a ¾ cubic yard 76in wide bucket to which a bulldozer blade can be fitted ; a scarifier and a ripper. This loader has a maximum lifting capacity of 4600 lb and its dump height is 9ft 4in.

The machine is powered by a Fordson diesel engine developing 57 b.h.p. at 1800 r.p.m., and its hydraulic system is supplied with fluid at 1750 lb per square inch by a Vickers intra-vane pump, with a capacity of 21 g.p.m., which is driven through a flexible coupling. To provide for heavy duty operation a 13in diameter sintered bronze clutch plate has been fitted in the transmission, and the cooling system is provided with a large capacity radiator and six-bladed cooling fan, a baffle being fitted behind the radiator to prevent the hot air from the fan being delivered into the engine enclosure. An exhaust deflector cap automatically closes when the engine is stopped and directs fumes away from the cab whilst the machine is operating.

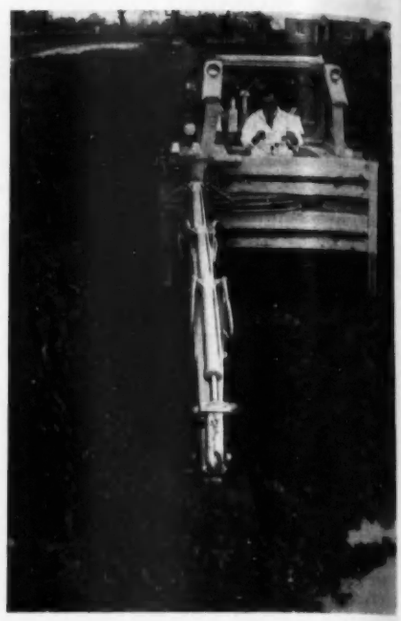
The main frame of the excavator is a welded plate box-section assembly and a 15-gallon fuel and a 30-gallon hydraulic fluid tank are integral with this frame. As already mentioned the king post and arm assembly are mounted on a carriage movable along a transverse structure forming part of the main frame. This carriage is held by through bolts and a back plate in the transverse frame. The bolts, passing through two slots along the frame, form shafts for rollers which facilitate movement of the assembly across the width of the machine when the arm assembly is being re-positioned. Movement of the assembly is effected by extending the dipper arm on one side of the machine with the bucket held against the ground. Upon the arm then being retracted the king post is drawn along the frame guides to its required working position, when it can be firmly locked by re-tightening the carriage bolts.

The vertical members at each side of the transverse frame provide the pillars for two telescopic stabilisers which are extended to raise the wheels at the rear of the machine clear of the ground during digging. These box-section stabilisers are fitted with easily renewable aluminium wear strips on all four sides, and they are extended and retracted by double-acting hydraulic pistons. A pin-jointed footpiece with anti-skidding spikes is fitted on the lower end of each stabiliser. By raising the body of the machine on these stabilisers at the rear and the loader bucket at the front a high degree of stability is imparted during digging operations.

The conventional digging arm is of conventional welded box section construction, and the various types of buckets are quickly interchangeable by the removal of two large pins with which they are coupled to the tipping arm and upper section of the main arm. To reduce the number of working spares necessary on a site the three hydraulic rams used on the digging arm and the four on the loader equipment are of the same size. Thus only one spare ram, if desired, or one set of seals need be held for field serving purposes. The king pin is turned through gearing by a double-ended hydraulic ram assembly mounted on its carriage. All the hydraulic flexible tubes are arranged to give easy accessibility for inspection and replacement when needed.

The digging and loading movements are each controlled through two Hamworthy valves operated by two multi-position levers, two further levers being used to control the raising and lowering of the stabilisers.

The large driver's cab provides all-weather protection and the introduction of a pivoted seat enables the operator to swing round from facing forwards after manoeuvring the machine into position to face rearwards to operate the excavator. Power steering reduces considerably the efforts required when manoeuvring the machine on heavy ground and the high ground clearance — 23in — facilitates movement over rough terrain. The six speeds available range from 2 m.p.h. in bottom to 13 m.p.h. in top gear.



Excavator cutting a trench with the bucket arm kingpin carriage set on one side of the front traverse frame to enable the machine to work close to a hedge

[Reply Card No. 1339]

Elapsed Time Indicator

To meet the needs of new applications in land and air transport, a voltage stabilising circuit using a zener diode has been added to the elapsed time indicators manufactured by Cass and Phillip Ltd., Mark Road, Adeyfield, Hemel Hempstead, Herts. The indicator has a 6V d.c. movement and can be fitted with an internal voltage dropping resistor for working on higher voltage systems such as 24V d.c. in aircraft. In such circumstances considerable voltage fluctuations are experienced, sometimes sufficient to prevent the indicator from starting, and it is for this reason that the stabiliser has been introduced. The maker states that the instrument will now operate satisfactorily at voltages varying between 16V and 30V on a nominal 24V d.c. supply. Another application is in diesel motive power on British Railways, where the indicators are operated from the 110V d.c. auxiliary system. Here an external voltage dropping resistor is fitted in the case containing the indicator.

An instant starting and stopping device is incorporated in the instrument. The complete mechanism, including the gear train, is suspended on four leaf springs spaced on 90 deg. arcs. The mechanism is then inserted in a polythene case, the leaf springs being located in grooves moulded in the case. This assembly is installed in a steel outer case and electrical contact is made through insulated terminals in the rear. The voltage stabilising system has been incorporated without increasing the physical dimensions of the instrument.

[Reply Card No. 1326]

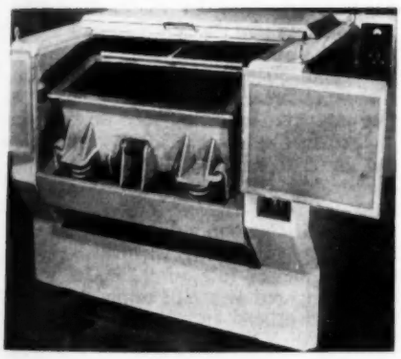
Vibrating Finishing Machines

In a recent demonstration at the Hemel Hempstead works of Roto-Finish Ltd., 39, Park Street, London, W.1, there was shown the firm's latest range of vibrating finishing machines, together with some special equipment it has developed. This vibrating technique for descaling, deburring, surface finishing and polishing components is not claimed to replace conventional barrelling methods but to extend the range of treatments available and enable a greater variety of components to be processed mechanically. Vibrating finishing is stated to process components more speedily than barrelling, afford closer control of finished accuracy and more efficiently finish recesses and inside faces in components. Furthermore, as the components and media are not sealed in a chamber but vibrated in an open topped tub they can be inspected at any time during a processing cycle.

The standard range of Roto-Finish vibrating finishing machines now available have workload capacities from 1 to 10 cubic feet and a typical machine can be seen in the illustration on this page. Each machine has a welded mild steel plate tub lined with abrasion resistant rubber. This tub is supported on coil springs in a subframe and it has a vibrating unit mounted externally on its base. The tub/frame assembly is supported in heavy duty bearings in the main frame of the machine by stub shafts at each end. A large sliding door in the top of the sheet-steel-clad main frame gives unrestricted access to the tub for loading purposes and with the two hinged front doors totally encloses the working area of the machine. A compressed air operated ram swings the tub forwards through 120 degrees for unloading purposes when all the doors have been opened.

During the vibrating cycle compound is delivered on to the top of the work load through a series of nozzles in a manifold along the rear edge of the tub. Compound gravitating to the base of the tub pours out into a storage tank below, and when the fines have settled out it is recirculated by a motor driven pump. All the switches, timers and other controls for the machine are conveniently grouped on one side panel.

The special units developed by the English Electric Company Ltd. for vibrating applications

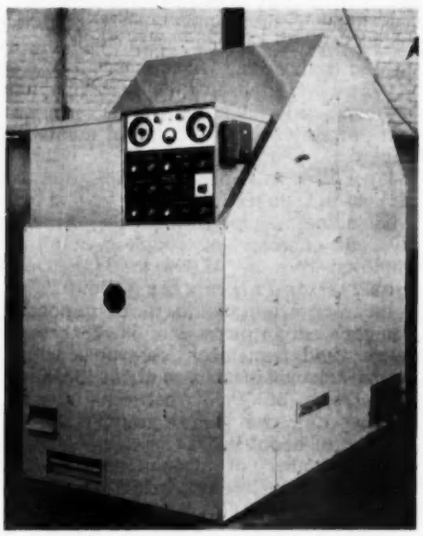


Vibratory finishing machine with doors open and tub being tilted forwards to emptying position

are used on all Roto-Finish machines: the tubs are vibrated at a constant frequency with an amplitude which is variable in accordance with the work requirements. In these English Electric units, which are available in capacities from ¼ to 10 h.p., vibration is generated by out-of-balance weights at each end of the motor shaft. Each of the weights is held by a single bolt and they can quickly be moved round the shaft to the out-of-balance position necessary to impart the required amplitude to the tub and its contents.

Using a standard tub and vibrating unit the firm has developed and built a compact semi-automatic finishing machine for the batch deburring of steel components to the special requirements of a factory in this country. This machine has a process cycle which is variable up to four hours and in each cycle it finishes 1600 components. It occupies a relatively small floor space and all the component parts are assembled in a structural steel frame totally enclosed by removeable steel panels. The vibrator tub is mounted in an elevated position at the rear and has over it a tiltable work hopper into which batches of components are loaded during a processing cycle.

The working cycle is started by the depression of a push button on the control panel and commences with the swinging over of the work hopper by a ram to deposit the components into the tub, which already contains the media. On completion of the return movement of the work hopper a switch is operated to start the tub vibrating unit and the motor of the compressed pump. A timer controls the period of the finishing process and when this is compound the vibrator and pump motors are stopped and switches are energised to start the tub tipping



Semi-automatic batch vibratory finishing machine

gear, two conveyors and a rising water pump. Each of these conveyors comprises an inclined belt of perforated metal pockets.

In the unloading cycle the media and components from the tub are tipped on to the first conveyor and as it carries its load towards the front of the machine dam, rinsing water is sprayed on to thoroughly clean the contents. At the end of its run the conveyor feeds the load on to a magnetic separator, the drum of which diverts the components into a discharge chute leading to a removable skip at the front of the machine. The media from the separator is diverted into the boot of the second conveyor on which it is elevated and deposited back into the tub. The period during which the conveyors, magnetic separator and spray rinse pumps operate is controlled by a timer and when this timer has completed its run the process cycle can be re-started automatically or manually as required.

An interesting development project now in an advanced state at the Roto-Finish works is a continuous feed vibrating finishing machine which is designed for a process time of about fifteen minutes and to take components up to 3in cube. This machine comprises two long vibrating work tubs in parallel with vibrating conveyors at each end. A series of scroll plates spaced along the length of each tub carries the media and components along from end to end. The components and media are fed into one end of one tub and the vibration combined with the scroll form serves to convey them to the other end of the tub where they are transferred to the second tub in which the direction of flow is reversed. The cross conveyor at the end of the second tub incorporates a separating screen which removes the components and allows the media to pass back into the leading end of the first tub. The processing compound is constantly circulated through the tubs by pumps from two storage tanks; with this arrangement two different processes can be carried out—such as deburring in the first tub and polishing in the second tub.

[Reply Card No. 1318]

Combined Water Tower and Chimney

An interesting structure in reinforced concrete has recently been completed at Belfast as part of the new Ulster Hospital, Dundonald. The designers have combined a chimney and a water tank into one structure, which is shown in the illustration herewith. The structure is 107ft high and the tank, which has a capacity of 100,000 gallons, is constructed in a wineglass or tulip shape. The hollow supporting stem continues up through the centre of the tank and contains the chimney flue which discharges above the roof level.

The whole structure is of reinforced concrete with the flue lining in firebrick. The external surface of the tank has a smooth concrete finish, the radial and horizontal lines of the shaped formwork panels being visible. The stem is circular, 7ft in diameter, with eight vertical fins or flutings. A circular walkway of aluminium rings the tank at its maximum diameter, supported on concrete beams cantilevered from the tank, with ladders from the ground and from the walkway to the tank roof, also of aluminium.

The tank itself is 51ft high with a maximum external diameter of 33ft. The wall varies in

Combined water tower and chimney at the New Ulster Hospital, Dundonald, Belfast

thickness from 13½in to 6in and is reinforced with ¾in circumferential bars on both faces and ¾in radial bars. The stem below the tank level is a 6in thick annular section with 1in vertical bars. The eight vertical fins are 8in wide, projecting 12in, and are incorporated in the structural design of the shaft. The whole structure is founded on an octagonal base 30ft wide and 6½ft thick. The tank is designed in accordance with the Code of Practice for water retaining structures. Tension in the concrete has been limited to 175 lb per square inch under the worst conditions. The tank is lined with asphalt on the inside to provide a waterproof membrane and smaller chambers are incorporated inside the tank at the top. The entry to the flue of the chimney is by a horizontal shaft at ground level.

The consulting engineers were Messrs. Felix J. Samuely and Partners, the architect Frederick Gibberd and the contractor Stewart and Partners Ltd.

INDUSTRIAL NEWS

Machine Tools

Statistics issued by the Machine Tool Trades Association giving monthly figures of deliveries, orders on hand and net new orders for machine tools for August, 1961, show that the total value of net new orders at £10,567,000 was 2 per cent less than a year earlier. Orders for the home market, which have been falling since the begining of the year, the Association says, were 14 per cent less than a year earlier. Export orders, however, have continued to come in at a high rate, and in August were 34 per cent more than in the first eight months of 1961, and 15 per cent more than in the corresponding periods last year.

Deliveries for the export market, valued at £2,094,000, were maintained during August, the Association states, while home deliveries, valued at £5,215,000, fell sharply to 2 per cent less than a year earlier. Taking July and August together, however, to minimise the effect of the later summer holiday this year, home deliveries were 9 per cent more than in the same period in 1960. Orders received continued to exceed deliveries and orders on hand at the end of August were still increasing. At the end of the month the industry's order book showed export orders worth £31,813,000 and home orders estimated at £86,986,000.

Fire Statistics

More than 62,000 fires occurred in buildings in the United Kingdom during 1960, according to figures given in "United Kingdom Fire Statistics 1960," which is published this week by the Joint Fire Research Organisation. This was the highest figure recorded since the Organisation began its statistical record in 1956. During the year local authority fire brigades attended 133,484 fires, and while this was considerably fewer than the record figure for 1959 when there was a very large number of outdoor fires in heathland, grassland and railway embankments, due to the exceptionally dry summer, it was otherwise the highest on record.

Fires associated with the use of electricity have been increasing for some years, the report states, and this trend continued in 1960. During the year 11,912 of the fires in buildings were associated with electricity, 2912 with the use of gas, 4812 with oil and 11,476 with solid fuels.

This week, October 30 to November 3, is National Fire Prevention Week, sponsored jointly by the Fire Protection Association and the Royal Society for the Prevention of Accidents, and appropriately, the British Insurance Association has released this week statistics relating to fire wastage. Fires in the United Kingdom during September caused material damage estimated to total £2,062,000, and although this is the lowest monthly figure of the year, it brings the estimated total of fire wastage for the first nine months of 1961 to £29,940,000—already higher than the total for any year before 1959. These figures were indicated on Monday by the Home Secretary, Mr. R. A. Butler, while opening the first National Fire Prevention Week.

Only four fires during September caused damage estimated at more than £100,000, the Association points out, and so far this year there have been no fires costing more than £1,000,000, which were a feature of the record fire wastage of £44,000,000 in both 1959 and 1960. Before then the annual fire wastage had never exceeded £28,000,000.

Unemployment

Between September 11 and October 16, 1961, the number of people registered as unemployed in Great Britain rose by 48,574 to a total of 365,607, according to provisional figures issued by the Ministry of Labour. The number of wholly unemployed was 322,377 while 43,230 were temporarily stopped from work. Unemployment rose by 58,072 among adults and fell by 9,498 among boys and girls. Unemployment, expressed as a proportion of the estimated number of employees, was 1·6 per cent in October, 1·4 per cent in September, 1961, and 1·5 per cent in October 1960.

Excluding school-leavers, the Ministry says, the number of people wholly unemployed rose by 42,094 to 318,183, the normal seasonal increase being about 27,000. In the two previous months the corresponding changes were an increase of 11,168 between August and September, compared with a normal seasonal increase of about 13,000 and an increase of 20,431 between July and August compared with a normal seasonal increase of about 9,000.

The number of people registered as unemployed in Northern Ireland on October 16, 1961, was 35,443, and expressed as a proportion of the estimated number of employees was 7·4 per cent.

In the five-week period ending October 11, 1961, employment exchanges in Great Britain filled 190,381 vacancies. The number of vacancies notified to exchanges but remaining unfilled on that date was 289,210, this being 38,939 less than in September. The normal seasonal decrease between September and October, the Ministry says, is about 13,500.

Export Credits

The Export Credits Guarantee Department has published details of the business declared under its "commercial" insurance during the third quarter of 1961. The gross value of all short-term and medium-term issued business including external trade declared as shipped during the quarter was £190,500,000 compared with £189,200,000 in the previous quarter and £180,200,000 in the corresponding quarter of last year. The number of short-term policies current at the end of the quarter was 5717 compared with 5537 at the beginning of the quarter, and 5112 at the end of the corresponding quarter of last year. The face value of these policies at the end of the third quarter was £835,400,000 as against £777,200,000 at the beginning of the quarter and £699,300,000 at the end of the third quarter of 1960. New medium-term business to the face value of £27,100,000 was transacted during the quarter, the Department states, compared with £13,100,000 in the previous quarter and £17,700,000 in the same quarter of 1960.

Specific policies issued during the quarter for business to a value of £27,100,000 included £5,500,000 for nuclear power plant, £8,200,000 for conventional power plants, £2,300,000 for vehicle assembly plant, £1,400,000 for chemical plant, and £1,100,000, ship mortage cover, for a cargo vessel. One claim paid during the quarter, the Department says, amounted to £314,000 in respect of default on a Middle East project.

Since their introduction in April (THE ENGINEER, April 21, 1961) the Department has sold 446 of its "small exporter" policies, under which cover for £638,000 has already been allocated. Under the new financial guarantee facility which was also announced in April, cover has been agreed in principle on five projects valued at about £69,000,000 with loan values totalling some £53,000,000.

Industrial Disputes

Statistics relating to the 231 stoppages of work due to industrial disputes in the United Kingdom, beginning in September, are published in the October issue of the *Ministry of Labour Gazette*. Forty-two stoppages which began before September were still in progress at the beginning of the month. The approximate number of workers involved during September at the establishments where these 273 stoppages occurred, the Ministry says, has been estimated at 78,200, this total including 10,000 workers involved in stoppages continuing from August. Of the 68,200 workers involved in stoppages beginning in September, 64,300 were directly involved and 3,900 indirectly involved. The aggregate of 180,000 working days lost during September included 54,000 days lost through stoppages continuing from August.

In the engineering industry in September there were sixteen stoppages involving 5600 workers which resulted in the loss of 22,000 working days. In the construction industries 7300 workers were involved in thirty-eight stoppages resulting in the loss of 33,000 working days; in the motor vehicle industry eighteen stoppages affecting 5200 workers resulted in 30,000 working days being lost; in the metal manufacturing group there were nine stoppages involving 4500 workers which resulted in the loss of 23,000 working days, and in coal mining 21,000 working days were lost in 147 stoppages involving 14,100 workers.

In the first nine months of 1960 there were 2168 stoppages in progress involving 647,000 workers and a loss of 2,256,000 working days, compared with 2103 stoppages involving 636,200 workers and a loss of 2,420,000 working days in the first nine months of this year.

Shipbuilding Statistics

The Shipbuilding Conference has announced that during the third quarter of the year forty-nine merchant ships of 160,000 tons gross were ordered from British shipbuilding firms. These orders have brought the total of contracts for the nine months to September 30 to 152 ships of 502,000 tons gross, the comparative figures for 1960 were thirty-eight ships of 63,000 tons and 176 ships of 417,000 tons for the third quarter and the nine months respectively. The industry's order book at the end of September stood at 379 ships of 2,791,000 tons gross and valued at £400 million, and compares with 437 ships of 3,494,000 tons gross one year ago. From these figures it is evident that new orders are not sufficient to fill the vacated berths.

PERSONAL AND BUSINESS

Appointments

MR. W. R. MAGOWAN has been appointed sales director of Davidson and Co. Ltd.

MR. C. W. PAGE has been appointed sales manager of the industrial division of Castrol Industrial Ltd. This is a newly created post.

PROFESSOR J. C. MITCHESON has been appointed chairman of the Geological Survey Board in succession to Sir Walter Drummond.

MR. DERYCK D. JEWELL has been appointed assistant manager, press services, for Massey-Ferguson (United Kingdom) Ltd.

MR. G. D. BYAM SHAW has been appointed to take charge of Crompton Parkinson's central organisation and methods service based on its London Office.

THE MINISTRY OF AVIATION announces that Mr. R. V. Whelpton has been appointed director of the Signals Research and Development Establishment at Christchurch, Hants.

FIBREGLASS LTD. has announced that Mr. John Creek has been appointed managing director in succession to Mr. Alan Hudson Davies who is now vice chairman of the Company.

MATBRO LTD., announces that Mr. Tony Darling, sales manager, has been appointed sales director, and that Mrs. Margaret Thompson, chief accountant, has been appointed company secretary.

THE MINISTRY OF AVIATION announces that Mr. J. E. Serby has been appointed deputy controller of guided weapons and that Mr. R. E. Sainsbury has been appointed director-general of guided weapons and electronics production.

OERLIKON ELECTRODES (GREAT BRITAIN) LTD. announces that its board of directors has been reformed, and Dr. Robert Lakner has been appointed managing director, and Mr. H. O. Willrich and Mr. F. W. Pinkstone have been appointed directors.

MR. H. C. BAADSGAARD, sales director of Nu-Swift Ltd., has, owing to advancing years, retired and resigned his directorships of Nu-Swift Ltd. and its associated Companies. Mr. Frank Tompkins, already a director of Nu-Swift Ltd., has been appointed homes sales director in his stead.

MR. GORDON WANSBROUGH-WHITE, assistant to the group organisation and methods officer, Metal Industries Ltd., has been appointed organisation and methods officer of the M.I. Group's biggest subsidiary, Brookhirst Igranic Ltd. Mr. J. H. Comley has been appointed production controller at the Bedford works of Brookhirst Igranic.

THE NATIONAL ASSOCIATION OF MARINE ENGINE-BUILDERS, at its annual general meeting in London last week, appointed Mr. Douglas G. Ogilvie, managing director of Hawthorn Leslie (Engineers) Ltd., as its chairman for the ensuing year, and Dr. Allan W. Davis, deputy managing director of the Fairfield Shipbuilding and Engineering Company Ltd., as its vice-chairman.

ULTRA ELECTRONICS LTD. has made several new appointments to its projects office staff. Mr. G. B. Wood has joined the company as a projects officer ; Mr. J. E. Hills has been appointed sales engineer (telecommunications) ; Mr. I. D. Condon, previously sales manager for Friden Ltd. is now marketing consultant to the Ultra Electronics automatic business equipment group; and another new addition to this group is Mr. J. B. Gillespie who is controlling home sales. To clarify the positions of the various members of the projects teams the titles of certain personnel have been changed. The following are now sales manager in their respective groups : Mr. A. E. Outten (telecommunications), Mr. R. J. Russell-Bates (control and instrumentation), Mr. V. G. Sampson (special products), Mr. R. A. Seal (automatic business equipment). The present projects officers in these groups will now be known as sales engineers and the title projects officer will apply only to two senior executives, Mr. G. B. Wood, mentioned above, and one other yet to be appointed. Mr. R. J. Williams is now projects manager.

Business Announcements

ROTO-FINISH LTD., is to open a branch factory at Cumbernauld Estate, Glasgow, Scotland, at the end of November.

MR. L. G. NORTHCROFT, chairman of Spirax-Sarco Engineering Ltd., started an overseas tour on October 30. He will visit the subsidiary company, Sarco International Corporation, New York, and the company's agents in Hawaii, New Zealand, Australia and Malaya, and the manufacturing unit in Bombay.

METAL DETECTION LTD., Moseley Street, Birmingham, 12, has moved to new and larger premises at Bickford Road, Witton, Birmingham, 6 (telephone EASt 3215).

ELECTROWEIGHERS (B'HAM) LTD., Moseley Street, Birmingham, 12, has moved to new and larger premises at Bickford Road, Witton, Birmingham, 6 (telephone EASt 3216).

HAGAN CONTROLS LTD, one of The Plessey Group of Companies, has moved from 14, Grosvenor Place, London, W.1. to Weedon Road, Northampton (telephone Northampton 260).

MR. R. H. CORBETT, by mutual agreement, relinquished his directorships and executive offices with Woodfield Rochester Ltd., as from October 31, 1961. He will be taking up an appointment as managing director of Craig Alford Ltd., Bath Hard Lane, Chatham, Kent.

THE OWEN ORGANISATION announces that all the personnel on the engineering side involved with the design and manufacture of Rubery Owen press brake guards have now been transferred to Boucher and Co. Ltd., Pike Mills, New Road, Kidderminster. Manufacture, erection and servicing of the press brake guard will now be carried out by that company.

CALEB BRETT AND SON LTD., 30, College Street, London, E.C.4, and YARSLEY TESTING LABORATORIES LTD., Clayton Road, Chessington, Surrey, announce the formation of Brett Yarsley Services, with laboratories at Chessington. Surrey, to carry out the analysis and testing of petroleum and related products and to provide technical services to the petroleum, chemical and shipping industries.

PAYNE PRODUCTS INTERNATIONAL LTD., Buckingham Avenue, Slough Trading Estate, Bucks., is to hold an exhibition of lapping equipment at its works from November 6 to November 10 inclusive between 9 a.m. and 5.30 p.m. daily. The exhibits will include a 72in "Lapmaster" with the latest British-built 48in and 24in machines, and the firm's "Monochromatic Light" for testing surface flatness will also be demonstrated.

JOHNSON, MATTHEY AND CO. LTD. has acquired the majority of the shares of the Belgian precious metal company, Pauwels Freres S.A. The future name of the Belgian company will be Johnson Matthey and Pauwels S.A. Mr. H. Limbourg, hitherto general manager, becomes managing director and Mr. L. Mendel the general manager, while Mr. R. Turner and Mr. P. G. Smyrk (director of Johnson Matthey) join the board of the Belgian company.

WALKER CROSWELLER AND CO. LTD., has formed a subsidiary marketing company in Belgium. The new company, Walker Crosweller S.A., 65, rue Montagne-aux-Herbes-Potageres, Brussels, is a wholly-owned subsidiary of the British firm. Chairman and managing director is Mr. Richard Walker, who is managing director of the parent company. Other directors of the Belgium company are Mr. D. L. Launchbury and Mr. C. F. Taylor, both of whom are also on the board of the parent company. General manager in Belgium will be Mr. Guy Dooms.

LA COMPAGNIE CONTINENTALE D'EQUIPEMENTS ELECTRIQUES, (C.E.E.), a new company has been formed by The English Electric Company Ltd. and the French firm, Les Exploitations Electriques et Industrielles, to carry out the manufacture and sales of all types of electric and electronic control equipment for France and the Common Market countries. The members of the board are Mr. Jacques Levy-Rueff, who is also appointed chairman, Mr. Georges Seban, The English Electric Co. Ltd., and Les Exploitations Electriques et Industrielles. Mr. Pierre Bouillot is appointed general manager.

BRITISH EXHIBITION IN HUNGARY.—The British Engineers Small Tools and Equipment Company Ltd. has organised an exhibition of precision measuring instruments and small tools made by seven member firms, which is to be held in Budapest from November 29 to December 3 next. In arranging this exhibition, designed to develop exports to Hungary and possibly neighbouring countries, the Export Publicity and Fairs Branch of the Board of Trade, the Central Office of Information, the British Legation of Budapest and Metrimpex—the Hungarian Trading Company for Instruments—have co-operated. The B.E.S.T.E.C. member firms to show their products include the Coventry Gauge and Tool Company Ltd., Brooke Tool Manufacturing Company Ltd. ; Hilger and Watts Ltd. ; Sigma Instrument Company Ltd. ; British Indicators (Sales) Ltd. ; L. M. Van Moppes and Sons (Diamond Tools) Ltd. ; and Joseph Gillott and Sons.

GAS PURIFICATION AND CHEMICAL COMPANY LTD,. the parent company of Smart and Brown (Machine Tools) Ltd., Sabel Works, Biggleswade, and The Tap and Die Corporation Ltd. have reached agreement for the sale to the latter of the whole of the machine tool division of Smart and Brown (Machine Tools) Ltd., including the works. The purchase price of £300,000 will be satisfied by the issue of Tap and Die ordinary shares. The electrical components division of Smart and Brown (Machine Tools) Ltd. is being retained by Gas Purification and Chemical Company Ltd. and will temporarily continue to occupy part of the present buildings, pending completion of new premises.

WICKMAN LTD. announces the conclusion of an agreement which provides it with exclusive selling rights within the United Kingdom of Great Britain and Northern Ireland for all British-built "Red Ring" products including gear shaving, gear honing, gear checking machines and equipment, gear shaving cutters, gear honing tools, and also British-built Leeds Bradner hobbing machines manufactured by Precision Gear Machines and Tools Ltd., Bodmin Road, Coventry. Additionally, Wickman becomes sole concessionaire within the United Kingdom for all "Red Ring" American machines and equipment built by the parent company—National Broach and Machine Company, Detroit 13, Michigan, U.S.A.

Contracts

THE VIBRATED CONCRETE CONSTRUCTION COMPANY has been awarded a contract by Braintree Urban Council for the construction of reservoir works for their Codham Mill water supply scheme. The reservoir will have a capacity of 3,000,000 gallons and the value of the contract is £83,650.

G.E.C. (ENGINEERING) LTD. has received an order, valued at over £10,000, for a sealed water-quench furnace for installation in the Burnley Works of the Lucas Gas Turbine Equipment Ltd. This furnace will be used for the annealing and hardening of various types of high-grade steel and steel alloys employed in the aircraft industry.

TAYLOR WOODROW CONSTRUCTION LTD. has been awarded a contract valued at about £600,000 by the Admiralty for a runway extension and other works at the Royal Naval Air Station, Brawdy, near Haverfordwest, Pembrokeshire. The main runway, some 900ft of which will be broken up and reconstructed, is to be considerably extended. The majority of the remainder of the runways will be resurfaced, and the 50ft wide permeter tracks broken up and reconstructed. Work, begun in October, will be completed in 12 months.

W. H. ALLEN SONS AND CO. Ltd. has received a contract from the Southend Waterworks Company valued at approximately £38,000 for pumping plant for the Nevendon Booster Station. Five 12in/10in horizontal-spindle, double-suction pumps are to be supplied, driven by Laurence Scott variable-speed motors. Two other contracts totalling approximately £103,000 have also been placed with W. H. Allen Sons and Co. Ltd. by the Southend Waterworks Company to the instructions of Messrs. Binnie, Deacon and Gourley, consulting engineers. The first contract covers raw-water pumps—four 12in suspended mixed flow pumps—and the second is for treated-water pumps, comprising three 14in/12in horizontal-spindle, two-stage, double-suction units, driven by 400-h.p. Laurence Scott variable-speed motors.

THE ENGLISH ELECTRIC CORPORATION of New York has received from The Grand River Dam Authority of Oklahoma, U.S.A., an order worth about 2,500,000 dollars (£900,000) for the design, manufacture and delivery of four 35,000 h.p., 90 r.p.m., Kaplan water turbines with a runner diameter of 220in, for a new dam and power station on the Grand River at Markham Ferry, Oklahoma. The turbines will be manufactured by John Inglis Company Ltd. of Toronto, an associate of The English Electric Company Ltd. The design work will be done by the company's hydro-electric division at Netherton, and the model testing and development will be done in the hydraulic laboratories at Rugby. The consulting engineers for the project are W. R. Holway and Associates of Tulsa, Oklahoma, who have also been responsible for the construction of an earlier dam at Pansacola on the Grand River. Markham Ferry will be a gravity and rock filled dam, operating at a mean head of 55ft. Besides providing a measure of flood control, the new power station will supply the State of Oklahoma with an additional 100,000kW of electrical power ; the completed dam and power house are due to be in operation by May, 1964.

Engineering Education in India

(By OUR INDIAN CORRESPONDENT)

WHEN the Delhi College of Engineering and Technology was opened on August 17, 1961, Sir Paul Gore Booth, High Commissioner for the U.K. in India, made a short speech. He cited the institution as " an active practical example of our keenness in the U.K. to co-operate in the growth of education, particularly technical education, in the Commonwealth ". He added that in the second half of the twentieth century all countries need engineers and technicians of high quality in large numbers. India needs plenty of them to promote the rapid growth which the country needs and to sustain progress once made. In this case the Government of India has provided the site and the funds for the building of the college. Britain, for her part, has made a two-fold contribution. Firstly, the U.K. Government acting through the Technical Co-operation Scheme of the Colombo Plan has undertaken to provide ten professors and two workshop superintendents. Secondly, private industry in Britain has provided the fund for the purchase of the equipment which has to be imported for the college. These funds totalling £250,000 were raised with the help of the Federation of British Industries.

The college will offer five-year courses in civil, mechanical, electrical and chemical engineering and in textile technology. In the first stage of development the undergraduate population will be 1250 students all residents at the college which occupies a site of 230 acres at Hauz Khas. Postgraduate courses for 300 students will begin in 1964. This will provide facilities for research for the further training of engineers at higher levels of study, and also refresher courses for industry. Some of the equipment presented by British industry has already arrived and that from local sources has been installed in readiness for the first session. Two large workshop and laboratory buildings have been completed, and the whole of the first and second year studies will be carried on in them while the main buildings are under construction.

The F.B.I. raised a fund for the provision of equipment for the Delhi College through a trust which is managed by a committee under the chairmanship of Sir Eric Coates. This committee is advised by a technical sub-committee presided over by Sir Willis Jackson, F.R.S., director of research and education of A.E.I. (Manchester) Ltd., who was recently appointed to the Chair of Electrical Engineering at the Imperial College of Science and Technology, London. Professor M. S. Thacker, Secretary to the Indian Ministry of Scientific Research and Cultural Affairs, is chairman of the governing body and Mr. R. N. Dogra is Principal of the college. A special feature of the college is the scheme for practical training which will be run partly within the college and partly in collaboration with industry. The programme and equipment for this are similar to those of the most advanced training establishments in Britain. In fine, the aim of the Delhi College of Engineering and Technology is to provide in India engineering education of the highest standard.

Turning to engineering education in general the undivided subcontinent of India had an area of 4,674,930km and a population not far short of 360 million. For this huge population there were just twenty-eight engineering colleges of university standard with an annual intake of 2250 students and an out-turn of 950 graduates ; and forty-one institutions of the polytechnic type with an intake of 3150 and an out-turn of 1150, technicians. To meet the ever-growing demands for engineers and technicians required for executing vast schemes of industrial power and irrigation development, the Indian Government embarked on a countrywide expansion programme of technical education. On the basis of the Sircar Report four higher institutes of technology were set up by the Central Government at Bombay, Kanpur, Kharagpur and Madras. Each of these was designed for undergraduate and postgraduate courses in selected branches of science and engineering and for research in these fields. They have all the status of a university with power to confer degrees. The student population in each is limited to 2000 including undergraduates, postgraduates and research workers.

The Central Government are also setting up nine regional engineering colleges in different parts of the country. The State Governments have established either by themselves, or at the initiative of private individual organisations, a large number of engineering colleges and polytechnics, the expenditure on which is met partly by the Centre and to some extent by private sources.

In these various ways sixty-nine engineering colleges (including four higher Institutes of Technology) and 156 new polytechnics have come into being in India since 1947. Today there are ninety-seven engineering colleges with an intake of 13,500 students and an out-turn for the present of 5310 graduates ; and 197 polytechnics with an intake of 25,600 students and out-turn at present of 10,400 technicians. In addition, there are trade schools and training centres for training mechanics and skilled craftsmen. Authorities of the engineering colleges in India face, however, the formidable problem of maintaining the standards of education (in the light of proliferation of colleges and polytechnics in the last twelve years) of these new institutions.

Calcutta's Power Problems

Load shedding operations of the Calcutta Electric Supply Corporation in the summer of 1961 have brought to the fore the acute power shortage problems facing greater Calcutta. The maximum demand of electricity for the Calcutta area reached 420MW last March (1961), and the rate of growth of demand in this area would be of the order of 30MW per annum. Therefore a conservative estimate of needs in 1971 would be 720MW. Turning to supplies the West Bengal Electricity Supply Board has planned to build a generating station at Bandel with an installed capacity of 300MW in four sets. The coke ovens power house of the Durgapur Industries Board is being expanded to install an additional capacity of 225MW in three sets. There would in all be nine sets in these two power stations. Now some 15 per cent of the power generated will be consumed by station auxiliaries and include losses in transmission to Calcutta. The Durgapur Station is committed to supplying power for the coke ovens and other local industrial enterprises. The railway electrification projects in the Sealdah Division, Howrah-Burdwan Chord and Howrah-Kharagpur sections will require at least 50MW. Allowing for one set to be out of commission for overhauling, and a second one kept in reserve as a standby, it is reckoned that the power available for supply to Calcutta from Durgapur and Bandel stations when fully equipped, will not exceed 310MW.

The Damodar Valley Corporation (D.V.C.) was permitted by the Government of West Bengal to supply power to Calcutta to the extent of 99MW from the D.V.C. grid. Additional supplies are not envisaged because the D.V.C. has no authority to supply power to Calcutta which is outside the statutory valley area. The four generating stations of the Calcutta Electric Supply Corporation (C.E.S.C.) are at the present time in a position to meet a maximum demand of 310MW provided all the sets at the new Cossipore station are in good condition In short, if all the projects in hand are commissioned according to schedule the power available in 1971 to Calcutta and the industrial area is estimated at 310MW (West Bengal projects) + 99MW (D.V.C.) + 310MW (C.E.S.C.) making a total of 719MW.

It is deemed essential for the security and continuity of electric supply to a great metropolis like Calcutta that all the power requirements must not be met by distant stations feeding through transmission lines. About half the total quantity, it is felt, should be generated in local stations. The C.E.S.C. quota of 310MW amounts to some 43 per cent of the total. West Bengal is subject to high floods and heavy cyclonic storms. In any year the transmission system from distant stations is liable to damage by natural calamities, and the supply of power to be interrupted. There have been such instances in Delhi, Bombay and Madras.

The useful life of a thermal generating plant is usually reckoned at twenty years. The old Cossipore station of the C.E.S.C. was commissioned way back in 1912. It is the technical efficiency of the C.E.S.C. which keeps it running and supplying energy to power-hungry Calcutta. The Southern generating station at Garden Reach, commissioned in 1927, is thirty-four years old. The Mulajore power station commenced operation in 1940, and is therefore twenty-one years old. Even the New Cossipore station is eleven years old, and has completed half of its useful life. By 1971 all these four power stations would either cease to function, or operate uneconomically and unreliably, with considerable loss in output.

The new Cossipore station is designed for an ultimate installation of two 30MW and three 50MW sets. At present two 30MW sets and only one 50MW set are installed. Provision exists for two more 50MW sets. In addition to the new 50MW set approved by the West Bengal Government, another new 50MW set could be installed here. Since the existing power stations are proved installations of sound design it would be expeditious and economic to draw up an early programme for their renovation.

Mokameh Ganga Bridge

During the nine decades of direct British rule in India seven railway bridges were constructed across the great Ganga river—six in Uttar Pradesh and one in Bengal (Hardinge Bridge now in East Pakistan). In Uttar Pradesh the river had been bridged in half a dozen places in a length of 609 milles, but there was no bridge in its course of 250 miles through Bihar. The traffic between Bihar and Bengal on the south, and Bihar and Assam on the north, was effected by trans-shipment through ferry services at convenient railway termini. The increased traffic in passengers and goods during the last war made the provision of a bridge across the Ganga river in Bihar a necessity. But only in 1948 was it decided that this river should be bridged at Mokameh in Patna district, 1048 miles below its source. At the site of the bridge the catchment area of the river is 293,000 square miles. A discharge of 2,750,000 cubic feet per second was adopted in the design, and further allowances were made for considerable seismic activity.

The Ganga bridge at Mokameh consists of fourteen main spans each 403ft and four 109ft shore spans two on either bank. The two-decked superstructure is in high tensile steel and carries a single broad-gauge railway track on the lower deck and a 24ft wide carriageway with a 6ft wide foot-path on either side on the upper deck. The main girders of the bridge 29ft apart are 60ft high. The bridge stands 35ft above the main flood level in order to provide for river traffic during flood time. The foundations of the bridge have been carried 150ft below the bed which is alluvial. In the river portion where the depth of standing water was 20ft to 25ft, steel caissons, fabricated on the bank, were floated into position with the help of compressed air and then sunk into place.

At the site of the bridge the river is 2·5 miles wide, but the bridge has been restricted to 6078ft only by blocking the river course on the north with a long approach bank. The flow is guided by a stone pitched sand and earthern bund 5000ft upstream and 1000ft downstream of the bridge. The quantity of earthwork for the bridge was of the order of 200 million cubic feet, of which a minimum of 75,000,000 cubic feet had to be completed within six months. The Mokameh Ganga bridge, one of the largest in the world, was completed within a working period of about five years.

CONTINENTAL AFFAIRS

by Our Continental Editor

Wavelength Standard Comparator

In accordance with a decision of the Eleventh General Conference on Weights and Measures, the metre is now defined in terms of a wavelength of krypton 86. An interferometer with photo-electric comparator now being set up at the International Bureau of Standards at Sèvres will enable metre standards to be compared within one part in 10^8 or better.

FOR many years the metre has been defined in terms of a prototype standard kept at the International Bureau of Weights and Measures at Sèvres, a definition which for various reasons has never been completely satisfactory. There always has been the possibility that the standard bar might get damaged or destroyed—a possibility which, unfortunately, does not appear so remote at present, as perhaps it once seemed to be. However that may be, there is another consideration which carries as much or even greater weight, which concerns the accuracy with which the metre is defined. Until now, this has ultimately been dependent on the precision with which a measuring microscope can be aligned on a scale marking. Some lack of definition is unavoidable even if the lines are diamond-engraved with the greatest care, and a certain personal error due to the lines having a finite width and slight irregularities cannot quite be eliminated.

A reading can be obtained with an accuracy of 1 to 0·1 micron or even better especially if a photo-electric microscope is used. This means that the metre is known to within one part in 10,000,000 or 100 millions. The great sensitivity of interferometric methods, however, promises a further improvement, by defining the metre in terms of the wavelength of light. This was officially proposed in 1957, the proposal being adopted in 1960 by the Eleventh General Conference on Weights and Measures. It was decided to redefine the metre as 1,650,763·73 times the wavelength *in vacuo* emitted by krypton 86 in its transition from the $2p_{10}$ to the $5d_5$ level of excitation.

The metre, defined in terms of a wavelength, at long last realises the ideal of those who first proposed this unit, of basing it upon a natural constant—originally the 10,000,000th part of the meridian-quadrant through Paris, now the multiple of an orange-red spectral line with a wavelength of, approximately, $0{\cdot}6057 \times 10^{-6}$m.

In order to put the new definition to use, it is necessary to employ an instrument known as an interferometric comparator. A longitudinal comparator of this kind, designed in collaboration by the International Bureau of Weights and Measures and the Société Genevoise d'Instruments de Physique, is at present being installed at the Bureau's laboratory at Sèvres. Comparators are known as transversal, longitudinal, or universal designs, according to whether the test scale and the reference standard are placed side by side under the measuring microscopes, one being interchanged with the other by a transverse movement of the support carriage; or whether they are placed in line—a set-up particularly convenient for checking small subdivisions—or whether both these arrangements are combined in a single instrument. The last-mentioned arrangement is useful for the measurement of coefficients of expansion, as two or more transverse carriages are available, which may be kept at different temperatures.

In the present case the longitudinal arrangement was adopted, i.e. the scale under test is moved lengthwise on a carriage while the divisions are viewed by measuring microscopes. The "standard" is constituted by the distance between two mirrors which are set up in line with the test scale. One of these is attached to the end of the scale and forms the moving mirror of a Michelson interferometer. It will be recalled that, in such an interferometer, a monochromatic beam is split into two equal components, one at right angles to the original direction, by means of a semi-reflecting plate, the so-called dividing mirror. The two partial beams are reflected back on themselves by mirrors, one of which (the reference mirror) remains fixed while the other is movable. In order to allow for the fact that one partial beam passes through the semi-reflecting plate while the other is reflected at the surface, a plane-parallel compensating plate is inserted into the path of the reflected beam. On recombining the return beams at the dividing mirror, a series of fringes is seen as the movable mirror is displaced, the succession of two fringes corresponding to a displacement equal to one wavelength. By contrast with comparators in which the scales under test are immersed in a liquid thermostat, the present instrument is "dry." It is completely enclosed in an insulated cylindrical cabinet which can be evacuated to eliminate convection currents. (Although the standard wavelength is specified *in vacuo*, it is not necessary to operate the interferometer in an evacuated space as a correction for air pressure can easily be made.)

All controls are operated from outside the cabinet. The shafts which transmit mechanical movements are made from insulating materials and pass through sealed joints which are air-cooled to dissipate frictional heat.

Fig. 1 shows the comparator before it was placed inside the cabinet. The scale is enclosed in a case of polished aluminium and is placed on a bed supported by the measuring carriage. The latter moves along the base on rollers which run in ways made as rectilinear as possible. The base is supported on three balls (one in a cone, one in a vee-groove, and one on a flat) on a massive slab which in turn rests on the concrete foundation on three feet situated directly below the balls supporting the base. This arrangement allows only compressive forces to be transmitted to the slab despite varying bending moments in the base due to the movements of the carriage.

This is of importance as the slab supports the two columns which carry the beam—clearly seen in the illustration—on which are mounted the two measuring microscopes. The whole assembly rests on a heavy ribbed concrete base which in turn is supported on a system of springs fitted with silicone oil dampers, so as to obtain complete freedom from vibrations. Also shown in the illustration is the interferometer which is attached to the underside of the beam. By operating the interferometer with polarised light and at the Brewster angle, parasitic reflections from the glass faces are avoided.

An arrangement is incorporated permitting the compensating plate to be tilted and to measure the angle of tilt, which, by changing the light path, enables fractions of interference fringes to be measured. The principle is to mount the compensating plate between two torsion bars the outer ends of which are fixed, and to exert a torque by means of two spiral springs attached at their inner ends to the bars and at their outer ends to a frame which can be rotated through a small angle by a precision worm and gear segment. A rotation of three minutes of this frame corresponds to a tilt of 0·02 of a second of the compensator, which in turn is equivalent to 0·001 of a fringe. This part of the mechanism also incorporates a solenoid and armature for oscillating the compensating plate at the frequency of the a.c. supply. By modulating the fringes in this manner, their separation may be determined photo-electrically.

Since the guideways of the base cannot be made sufficiently true to keep the movable mirror of the interferometer accurately parallel, adjustments must be made after each displacement by elastically deforming one of the minor supports by means of a differential screw.

Readings of the test scale are carried out by two photo-electric microscopes. One of the advantages of using this kind of instrument is stated to be the almost complete elimination of

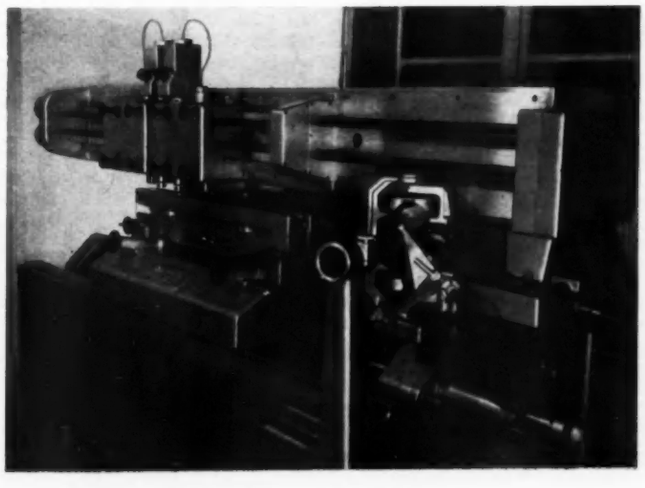
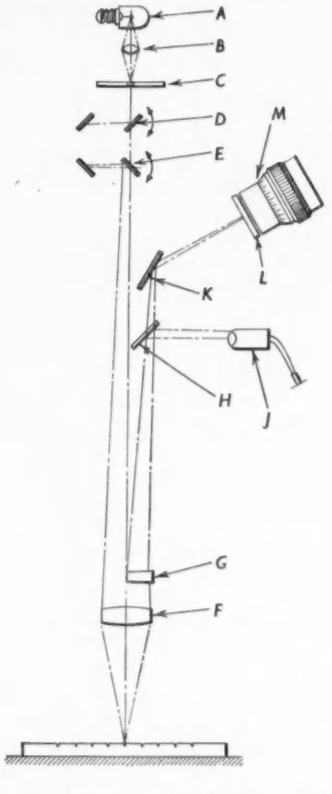


Fig. 1—The scale under test is placed on the carriage. On the overhead crossbeam are seen the two photoelectric microscopes. The interferometer and parts of the drive are on the right. The instrument is seen here outside the airtight cabinet in which it will be enclosed when in use

CONTINENTAL AFFAIRS *(Continued)*

human error. Moreover, by taking remote readings, the influence of heat radiation from the observer is eliminated.

The design of the photo-electric microscope is shown in Fig. 2. The image of an illuminated slit is focused on to the scale by the microscope objective lens, with two electrically-vibrated mirrors inserted in the beam. By employing these mirrors separately or in combination, three amplitudes of sweep of the slit image are obtainable corresponding to fields of measurement of 10, 200, and 1000 microns. Moreover, by feeding one of the mirrors with direct current and gradually varying this current, a very fine



A—Lamp bulb.
B—Condenser lens.
C—Slit.
D,E—Oscillating mirrors.
F—Objective lens.
G—Prism.
H—Semi-reflecting mirror.
J—Photo-electric cell.
K—Mirror.
L—Graticule.
M—Eyepiece.

Fig. 2—Diagrammatic arrangement of photo-electric microscope

zero adjustment can be made so as to align the scale image with the optical axis of the microscope.

The image of the scale is allowed to fall on a photo-electric cell using a prism and semi-reflecting mirror to deviate the beam away from the axis of the microscope. A portion of the light passes through the semi-reflecting mirror and, after reflection by another mirror, reaches a graticule eyepiece (which is fitted to enable preliminary adjustments to be made visually).

The light received by the cell, and consequently the photo-electric current, is a function of time, passing through a minimum twice during each period of vibration of the mirrors as the slit image sweeps the scale line. If the scale line is on the axis of the microscope, the current minima are evenly spaced as in Fig. 3(a), if off-centre, the current is as in Fig. 3(b). These signals are transformed electronically into the square wave forms shown in the lower part of the illustration.

Since it is required to make the measurement not in terms of time, but in terms of swept distance which is a sinusoidal function of time, it becomes necessary to linearise the sweep/time

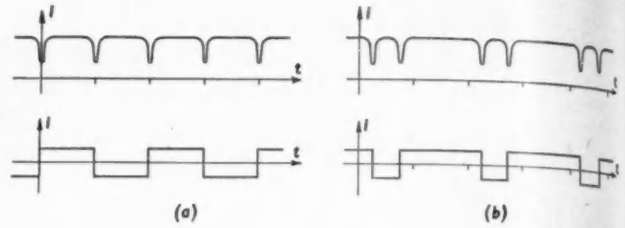


Fig. 3—Photo-electric current (top) and resultant square wave (bottom) plotted against time

function. For a sufficiently small segment near the base line, the sine curve approximates a straight line, but with swept fields of 200 or 1000 microns, for this to be correct a total sweep of several millimetres would be necessary.

Accuracy depends on the stability of the oscillating mirrors and the electronic and associated circuits, as well as the size of the divisions on the reading scale which can be conveniently read. The limiting stability is of the order of 10^{-4} times the width of the microscope field, while the size of scale division adopted as being still comfortably readable was 0·65mm. These two facts give an effective width of the reading scale of $10{,}000 \times 0{\cdot}65\text{mm} = 6{\cdot}5\text{m}$, amounting respectively, to magnifications of 650,000, 32,500, and 6500 times for swept fields of 10, 200, and 1000 microns.

In order to transform the sinusoidal scale into a linear scale 6·5m long, a reading instrument is incorporated in the control desk. This instrument is common to the two microscopes. It incorporates an optical system similar to that of the microscopes themselves. A lens projects the image of an illuminated slit on to a photo-electric cell, the light passing through three correcting glass plates, one measuring glass plate, and two glass plates which can be oscillated by means of coils and magnets.

The measuring glass plate is mounted on a 30 deg. gear segment which can be turned by a worm. Also attached to the segment are three cams which serve to tilt the correcting plates each of which corresponds to one of the available magnifications. Their function is to correct, for the fact that the movement of the slit image caused by the measuring plate and the two oscillating plates is not truly sinusoidal, since refraction, unlike reflection, is not strictly proportional to the angle of incidence.

The oscillating plates are operated at the same frequency as those of the microscopes. If the measuring plate is normal to the optical axis the output from the photo-electric cell, transformed electrically into a square wave, is similar to Fig. 3 (a), but if the plate is inclined, the current is as shown in Fig. 3 (b). Addition of the microscope and reader currents produces an error signal which causes a servo to tilt the measuring plate until the two currents are in phase, when the error signal disappears. Under those conditions, the displacement of the line on the test scale from the optical axis of the microscope is directly proportional to the tilt of the measuring flat, i.e. to the angle of rotation of the gear segment. This angle can be measured —a precision of $10^{-4} \times 30$ deg., or about ten seconds of arc being fairly easily attainable—so that the problem of linearisation of the reading scale is solved.

For the purpose of indicating the readings, the worm driving the segment is directly coupled to a cylinder which is geared to two further cylinders in the ratio 1 : 10 and 10 : 1, so that the three cylinders respectively show units, tenths, and hundredths. The top cylinder carries a single-turn helix which shows as a sloping line moving across a slot in the instrument dial as the cylinder is rotated. The middle and bottom cylinders each carry one single-start red helix which makes two turns, and one two-start green helix which makes one turn.

The top slot carries two scales, the upper red scale having ten divisions and the lower green scale, twenty. The middle and bottom slots each have twenty divisions. All scales have a central zero, about which positive and negative readings can be taken. For reading the 10 micron and the 1000 micron field, a red light is switched on, while for the 200 micron field a green light is used. The red light makes the green figures and lines stand out in black while the red figures and lines fade into the background, and *vice versa*. This makes it clear which set of figures and lines is to be used for a particular range.

It has already been mentioned that all controls are operated from outside the instrument cabinet from a control desk. In addition to the microscope reader, the desk incorporates telemeasuring devices for positioning all movable components. Synchronous transmitters are used to drive the measuring and microscope carriages at speeds which can be varied between 0 and 10mm per second.

Heat sources inside the cabinet are kept down to a minimum. They comprise the microscope lamps, which are of very low power, the electromagnets, and friction. The interior walls and the interferometer beam are lined with polished aluminium. This is done in order to facilitate equalisation of the temperature, which must be known to within 0·001 deg. Cent.

For interferometric measurements the carriage will be moved by means of either a very highly geared manual drive, or a magnetostrictive drive.

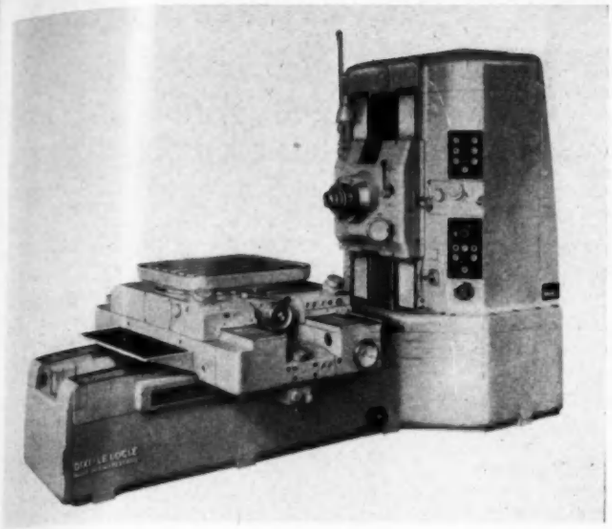
In addition to comparing line standards with the wavelength standard, it will be possible to compare two line standards, as with an ordinary longitudinal comparator, and also, with the help of a Fabry Perot etalon, to compare end standards up to 1m long with line standards.

Horizontal Jig Boring Machine

An important addition to the range of horizontal jig boring machines made by Dixi S.A., Le Lode, Switzerland, is a new machine with both optical and automatic positioning equipment. The automatic numerical positioning equipment, which enables settings to be made to within 0·00005in, can be operated directly from a keyboard, by tape strips or by endless perforated tapes. This " 3S " machine, illustrated opposite, has a 32in square, rotatable, work table with a longitudinal travel of 28in along the bed and a transverse travel of 21½in. The 3·35in diameter spindle is adjustable vertically from 2in to 23·6in above the table surface.

The spindle is driven through belts from a d.c. motor and a Ward-Leonard control system with a ratio of 1 : 7 and two interchangeable pulleys give two stepless spindle speed ranges which can cover either from 32 to 1600 r.p.m. or 50 to 2500 r.p.m. The headstock is carried on a prismatic guide on the front column and a flat guide on the rear column, transverse forces being taken on the front column only, which is of stronger construction than that of the rear for this purpose. All longitudinal transverse and vertical movements are hydraulically controlled, with stepless speeds from 0 to 118in per minute, and the pumps, and oil tanks for the hydraulic system are accommodated separately from the machine.

The controls on the machine itself have been designed for simplicity in operation and are conveniently grouped on the front column. The upper group of controls are for the less frequently used operations (main switch; trans-



Jig boring machine with manually controlled precision optical positioning and incorporating automatic positioning equipment

former-setting and hydraulic system switch), the lower group contains the switches for the more frequently required operations (spindle speed, direction of rotation, &c.). Two small directional levers at the foot of the column control movements of the table and headstock whilst a regulating lever with a preselector ring for a given feed for the hydraulic system is mounted between the two control groups. After setting has been effected the slides are automatically locked by hydraulic-mechanical equipment.

The optical setting equipment for the slides comprises chrome-plated steel scales graduated to within ±0·00005in which are used with projection screens. It enables the machine, when required, to be operated under manual control completely independently of the automatic system. For the automatic control system there is provided a console which can be set in any convenient position near the machine. This equipment permits direct positioning for the main co-ordinates by use of a keyboard and it can also be used for punching its own control tapes for a production run when machining the first component of a batch under keyboard control. Further controls within the console are arranged for controlling the direction and stopping the spindle, starting and stopping quick traverse, and selecting and engaging different feed and spindle speed rates. The automatic positioning process is effected by electronic coarse adjustment and optical-electronic fine adjustment means, which act in succession on a magnetic valve fitted in the hydraulic circuit of the machine. This valve controls the direction of movement and the feed, as well as the precise movement to the figure that has been set. Transparencies on the control panel can be arranged to light up at appropriate times to indicate when such operations as changing tools or turning of the table, which cannot be controlled from the tape, are needed. The machine stops for such operations and when they are completed it can be re-started under tape control by depression of a push button.

Preservation of Milk

A method of milk sterilisation, which makes it possible to store milk for a prolonged period of time, has been developed by a team of researchers at Alnarp, the Swedish University College of Dairy Engineering, in collaboration with AB Separator, the Swedish Alfa-Laval Company. Milk processed according to this method can be stored at least four weeks at temperatures normal in the tropics without any change of flavour, colour or nutrition value, it is claimed. A fully automatic sterilisation plant, the "Vacu Therm Instant Sterilizer," has been developed in which the milk is preheated and then given a shock treatment by being heated to 140 deg. Cent. by jets of hot steam, then quickly chilled by evaporation in a vacuum chamber. This vacuum processing also frees the milk from any feed or similar taste. Milk obtained by this process is stated to be completely free from micro-organisms and thus suitable from the bacteriological standpoint for prolonged keeping.

The exact processing temperature in the Alfa-Laval "Vacu Therm Instant Sterilizer" is achieved partly by an automatic regulating system and partly by a patented automatic "watchman" which returns insufficiently processed milk to the inlet of the sterilising plant. A special automatic device also ensures that the structure of the milk is unchanged during the process. To ensure absolute sterility before the processing begins, another automatic device cleans and sterilises the machine according to a fixed time and temperature programme.

The operational cost of the installation is claimed to be low owing to the use of heat regeneration. Moreover the installation can be adjusted to sterilise varying quantities of milk. For use in conjunction with this equipment there are now available on the market low-price plastic-coated containers which can be filled and sealed by fully aseptic machines.

Tidal Power Station near Murmansk

The design has been approved and surveying work has begun in connection with the construction of Kislogubskaya power station, a small tidal power station in Motovsky Bay, in the Barents Sea, north-west of Murmansk. The station is to have an installed capacity of 1·2MW and is to operate continuously by combining it with river power stations and using reversible sets. In order to reduce the difficulties presented by the remoteness of the site and the rocky nature of the coast, the station is to be built in the form of a floating dock which will be towed from near Archangel to Kislaya Guba and sunk there on a prepared foundation. Three further tidal power stations for the Kola grid are being designed. One of these, Mezenskaya Station, is to have a capacity of 1300MW. The amount of tidal power available in the White Sea is very considerable. Thus, if the shallow part of Mezensky Bay were shut off by a 60 mile long dam, it would be possible to generate 14,000MW (compared with 2500MW of the new Volga (Stalingrad) power stations).

Electric Wrist Watch

An electro-mechanical wrist watch has been put on the market by Henri Sandoz and Fils, La Chaux-de-Fonds, Switzerland. The movement, made by Fontainemelon Watch Manufacturing Company, Le Landeron, has a balance which acts both as a regulating organ and as a motor. As our illustration shows, in addition to the normal balance and roller, the balance staff carries a mobile armature with four arms soldered underneath the balance, and a collet fitted with a contact finger. As the balance wheel swings towards its equilibrium position under the action of the hairspring, the finger touches the apex of a double contact spring, the two limbs of which form an isosceles triangle attached at its base to a holder. At their midpoint, the springs each carry an auxiliary contact. As the assembly is bent over by the moving finger these auxiliary contacts, and contact with the finger itself, are made and again broken as the angular movement of the finger increases. Closing of the contacts magnetises the stator coil and thereby gives an impulse to the mobile armature. A diode and resistance in parallel with the magnetic winding prevent burning of the contacts.

There are thus two impulses in a complete period of vibration. The movement of the balance is transmitted to the train by way of the click mechanism. Every time the balance passes its point of rest, the impulse pin shifts the click lever from one banking pin to the opposite one. During the supplementary arc, the click lever is held against the respective pin by the attraction of a lever magnet fixed under the plate, on a magnetic shunt fixed on the arbour of the click lever. In every swing the click lever drives the click wheel half a step. The click wheel is stopped after each angular shift by a friction spring. From the click wheel, the motion is transmitted to the hands by a train of the usual design. Electric power is supplied by a small dry cell, or alternatively an accumulator, housed in the waterproof back of the watch. The accumulator can be recharged by means of a new 1·5V flashlight cell, while the dry cell is replaced by a new one when exhausted.

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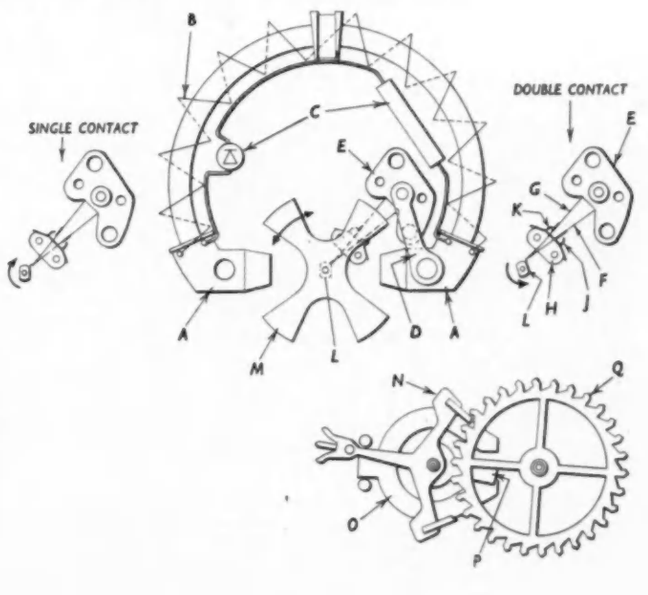
A—Stator with pole pieces.
B—Stator winding.
C—Diode and resistance in parallel.
D—Current connection.
E—Contact unit.
F and *G*—Contact springs.
H—Contact plate.
J and *K*—Contact breaks.
L—Collet with contact finger attached to balance staff.
M—Armature, attached to balance staff.
N—Click lever.
O—Lever magnet.
P—Magnetic shunt.
Q—Click wheel.



Principle of electric watch movement with impulse motor incorporated in balance

THE AMERICAN SCENE

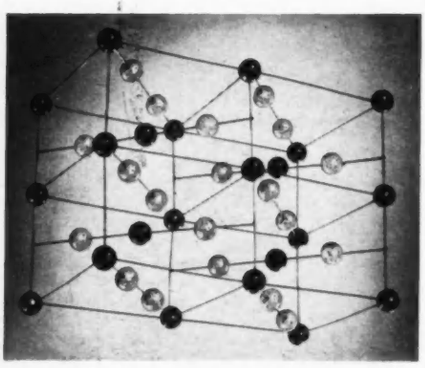
By Our American Editor

Solid-State Physics Work at the National Bureau of Standards

To help solve the problems posed by semiconducting materials and thus provide data needed for their effective application the National Bureau of Standards conducts a programme of solid state research sponsored in part by the U.S. Department of Defence. Such a programme forms a vital part of the overall scientific effort which has been brought to bear in the area of the solid state over the last few years. This branch of physics, seldom heard of as little as fifteen years ago, is now one of the most active fields in present-day science. Since the invention of the transistor at the Bell Telephone Laboratories in 1948, *demands have continued to increase not only for new semiconducting materials but for a better understanding of available materials which will allow a wider scope of application.*

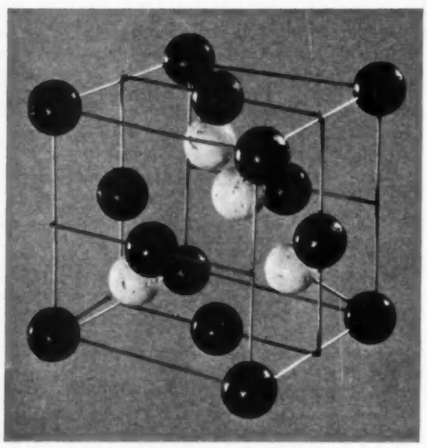
ALTHOUGH the technological application of semiconductors has played a great part in the rapid progress made in solid-state research, the basic aims of the field are of a more fundamental nature. Primarily, solid-state physics attempts to interpret the physical properties of matter in terms of the microscopic behaviour of electrons, nuclei, and lattice vibrations. Advances toward this goal were first made during the thirties with the groundwork laid by Wilson and Sommerfeld for a quantum mechanical theory of electronics in crystals, and with the basis for understanding lattice properties provided by Born's work on crystal dynamics, and Peierl's introduction of the phonon concept. Toward 1940, solid-state physics came into its own, probing the characteristics of matter in terms of these new theories.

The materials first investigated on the basis of electron and lattice theories were germanium and silicon—the elements employed in the transistor. As the scope of investigation broadened, silicon power rectifiers and voltage regulators, photo-detectors for the infra-red, and thermo-electric devices for power conversion or refrigeration were developed. Increased activity in solid-state research at very low temperatures has more recently produced devices like the maser (a microwave amplifier) and the cryotron (a super-conductive computer component). Studies of imperfections, such as vacancies, interstitials, and dislocations, have also pressed forward during the last ten years, and have recently made it possible to increase the strength of materials, especially metals. With the growing need for materials to withstand very high and very low temperatures, the results of such studies find immediate technological application.



Model of titanium dioxide in the crystalline form of rutile which can be made semiconducting by the addition of foreign ions or the loss of oxygen, represented by the light balls

The programme of research presently underway at the National Bureau of Standards, Washington, D.C., deals with the electrical, thermal, optical, mechanical, and magnetic properties of certain materials. The behaviour of these solids is studied by measuring either individual properties or combinations of properties such as thermo-electric power and electrostriction. The data thus obtained lead to a better understanding of the factors that cause solids to exhibit particular characteristics, and also yield much information about the structure of the solid-state. Such studies allow the potentialities of a material for practical application to be evaluated.



Zinc blende crystal structure representative of the III-V binary compounds, which are now finding application in the semiconductor field

The Bureau has been involved in the general effort to arrive at an understanding of semi-conducting solids since 1949, when work on the properties of rutile was initiated. These studies led to a better understanding of the electronic behaviour in rutile and eventually resulted in the development of a useful device, the titanium dioxide rectifier. In 1952, attention was turned to a new class of materials, the III-V compounds—binaries formed between elements of the III-B and V-B columns of the periodic table. The Bureau was the first to undertake research on this group of new semiconductors. During the following two years many crystals of aluminium antimonide, gallium antimonide, and indium antimonide were prepared, and their electrical and optical properties investigated. Later on, this research was extended to include studies of mechanical and magnetic behaviour. InSb (indium antimonide) was shown to be an extremely interesting material for both basic research and for application to infra-red photodetectors and galvanomagnetic devices. Consequently, appreciable effort is still devoted to InSb.

Other materials studied during the last five years are magnesium-tin and semiconducting gray tin. Recently, attention has again been focused on TiO_2 as a result of heightened interest in thermo-electric devices, which has stimulated the study of oxide semiconductors, especially the oxides of the transition metals. Titanium dioxide was chosen as a prototype of this class and also as an example of a high-temperature semiconductor.

The programme of research on the materials can be broken down into the following projects:

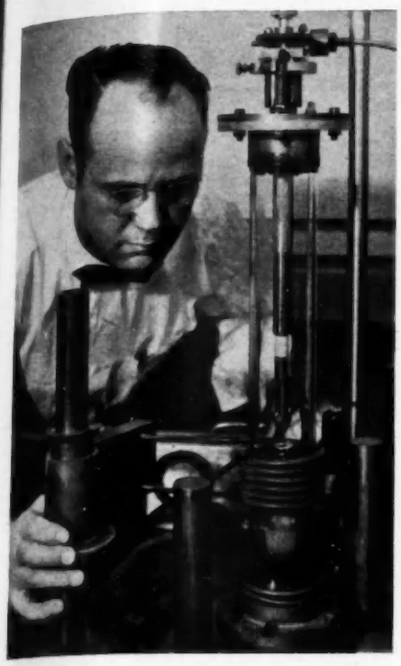
Representative semiconductor crystals: bismuth telluride at upper left, the remainder is indium antimonide

(1) crystal growth and sample preparation; (2) measurement of electrical properties including conductivity, Hall effect, magnetoresistance, and thermo-electric power; (3) studies of optical absorption and photo-conductivity; (4) determinations of the lifetime of optically excited charge carriers; (5) measurements of the mechanical and electromechanical properties, which include elastic constants, anelastic effects, piezo-resistivity, and piezoelectric effects; (6) studies of nuclear magnetic resonance; and (7) further development of solid-state theory.

Crystal Growth and Purification

As solid-state materials are evaluated on the basis of electron and lattice theories, they must be studied in their crystalline form. Therefore, crystal growth and purification are a vital part of the solid-state research programme. Crystals of the III-V compounds are prepared by the Kyropoulos technique in which a seed crystal is immersed in a melt and then slowly removed. In this way, a large crystal is formed. During the last four years, over 100 crystals of InSb, mostly monocrystalline, have been grown by this technique.

To obtain information about the structure of the solid-state, it is often necessary to have very pure materials or materials with known contamination or doping. Therefore, before the final crystal growth, the crystal-forming substance is purified by the zone melting technique, in which molten zones move through the substance leaving a purer material in their wake. Indium antimonide with purities as high as 10^{14} or 10^{15} impurities per cubic centimetre (i.e., 1 to 10 parts in 10^8) has been obtained with this method.



Furnace installation for the growing of large single crystals by the Kyropoulos technique

Electrical Property Measurements

The first measurements made on each new conducting crystal are of an electrical nature. Conductivity is of primary interest and is determined from the potential drop along a sample of rectangular shape. Additional information is then obtained by studying the Hall effect—the electromotive force set up by the migration of charge carriers in a current-carrying conductor subjected to a magnetic field at right angles to the direction of the current flow. The sign of the Hall coefficient distinguishes between n- and p-type semiconductors ; in the former, the current is carried by negative charges or electrons, while in the latter, the conduction is due to positive carriers or holes. A third property investigated is the thermo-electric effect—the voltage between two ends of a specimen kept at different temperatures.

From the variation of these quantities with temperature, it is possible to obtain the information needed to understand the mechanism of conduction in the crystal and to evaluate the material for use in practical electronic devices. This information includes : (1) Intrinsic and extrinsic energy gaps ; (2) number of charge carriers ; and (3) mobilities of electrons and holes. Measurements of the conductivity, Hall effect, and thermo-electric power are made down to liquid helium temperatures, as are most of the other property measurements on semiconductors. Conductivity and thermo-electric power have been determined up to 1000 deg. Cent. Conductivity and Hall effect measurements on the III-V compounds have shown that this group of materials displays widely differing properties. Energy gaps range from 3·0 eV to 0·16 eV, and mobilities from 10^2 square centimetre per V-sec to 10^5 square centimetre per V-sec. As a material can usually be found which has properties tailored to a particular application, this class of compounds is very important.

In the study of electrical properties, several phenomena of fundamental importance have been discovered. For example, during a measurement of the magnetoresistance of InSb as a function of magnetic field H at liquid helium temperature, it was observed that its behaviour was not quadratic in H as expected from classical considerations, but showed instead several oscillations. Subsequent investigations indicated that these oscillations were periodic in $1/H$. This phenomenon is closely associated with the oscillatory behaviour of susceptibility, which has been observed in several metals and is known as the de Haas-Van Alphen effect. The effect occurs when the electron mean-free path becomes a circular orbit. Under these circumstances, quantisation of the electron orbits must be taken into account ; the electronic energy states become discrete and produce oscillations in the diamagnetic and transport properties.

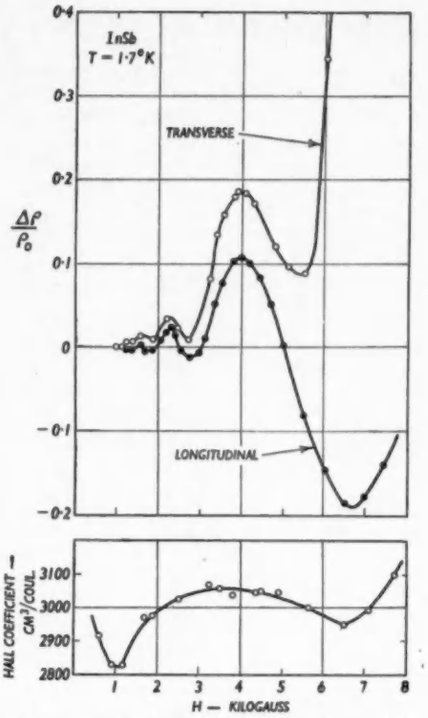
Optical Measurements

The present interest in employing semiconductors as infra-red photodetectors requires a better understanding of the principles of the photoconductive process and information on new materials. To provide these data, which are essential for extending the application and reliability of detectors in the infra-red, the Bureau measures absorption spectra and photoconductivity. These investigations are carried out as a function of temperature, and interest is mainly focused on the infra-red region. Some of the materials that have been studied are gallium antimonide, cadmium antimonide, indium antimonide, and magnesium-tin ; the intrinsic absorption edges of these substances lie in the 1 to 7μ wavelength range.

Recently an investigation of the photoconductive response of copper-doped InSb showed that fairly large photosignals can be obtained at liquid helium temperatures in the far infra-red range up to 35μ. Interesting quenching effects were found in n-type InSb containing a slight amount of copper impurity.

Carrier Lifetime Studies

Carrier lifetime τ—the length of time that an electron (or hole) takes part in the conduction process before recombining with a hole (or electron) in the valence (or conduction) band—is one of the major parameters governing the conduction process in solids. Its numerical value is, therefore, of great importance in evaluating materials for application as rectifiers, transistors, and photodetectors. The Bureau carries out studies of carrier lifetime which, in addition to furnishing a critical value, provide a means of investigating the recombination and trapping processes in crystals.



Transverse and longitudinal magneto resistance $\Delta\rho/\rho_0$ and Hall coefficient determined for n-type InSb at 1·7 deg. K.

Values of lifetimes are derived from measurements of the photoconductivity and the photoelectromagnetic effect. The photoelectromagnetic effect is a kind of Hall effect in which the charge carriers are produced by incident light and deflected in the sample by a magnetic field. The current is perpendicular to both the incident radiation and the field. It is proportional to $\sqrt{\tau}$, while the photoconductive signal is proportional to τ. Hence the value of the lifetime is obtained directly from the ratio of the two signals.

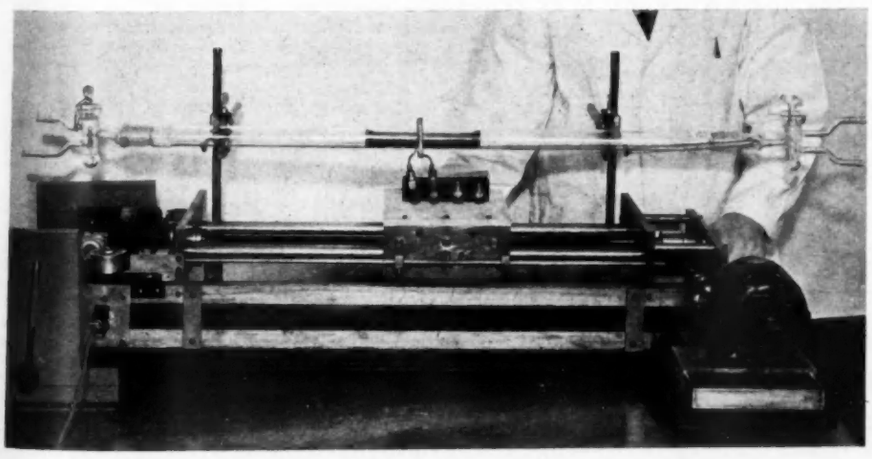
Mechanical and Electromechanical Studies

The Bureau investigates the basic nature of semiconductors by obtaining data on the mechanical properties of crystals. This information is also essential for the effective application of the semiconducting materials. The mechanical behaviour of semiconductors can be studied by means of several different experiments, some giving information about the state of the lattice and others about the electron assembly. An example of the former is a determination of the elastic constants. These constants have been measured on single crystals of indium antimonide and the results were correlated with optical and thermal data. It appears that the values of the elastic constants are indicative of the partly ionic character of this compound.

Other experiments depend on the interaction of the lattice structure and the outer electrons. A recent measurement of the resistivity of n- and p-type InSb under the influence of tensile stress has confirmed the energy band structure of this material. The study of internal friction is very well suited to investigations of imperfections. The temperature or frequency dependence of the mechanical damping often reveals relaxation peaks and attenuations, which can be related to dislocations, vacancies, interstitials, chemical impurities, and other irregularities. Some measurements of this kind have been made on InSb up to the melting point (523 deg. Cent.). The experimental method used was the composite oscillator technique in which the sample is driven by a quartz transducer. Similar measurements on TiO_2 have recently been started.

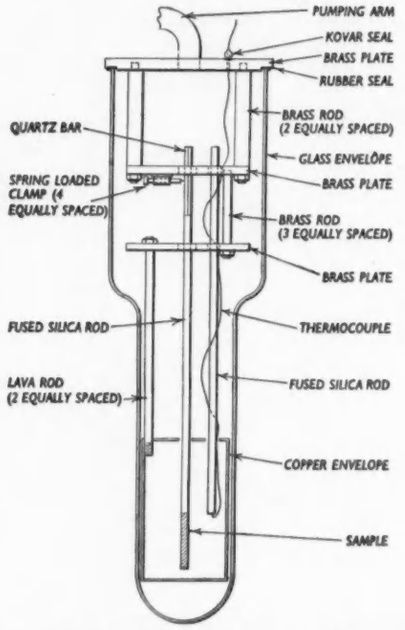
Nuclear Magnetic Resonance

Since its discovery fifteen years ago, nuclear magnetic resonance has proved to be one of the



Zone melting apparatus for the purification of crystal-forming substances, such as indium antimonide

THE AMERICAN SCENE *(Continued)*



Experimental apparatus for measurement of internal friction in semiconductor materials employing the composite oscillator technique, with a quartz transducer driving the sample

most useful techniques for studying solids. The Bureau makes use of this method to investigate defects and impurities in semiconducting materials. The solid being studied is contained in the coil of a resonant circuit between the poles of an electromagnet. As the circuit is tuned through its resonant frequency, the nuclei in the sample switch from one orientation to another with a net absorption of energy. The relaxation time—the time nuclei remain in the higher energy state—is measured by pulse equipment.

This series of investigations was initiated in 1956 with the determination of the temperature dependence of the spin-lattice relaxation time in sodium chloride. During the past year, emphasis has been placed on the spin-lattice interaction in AlSb as deduced from the resonance of the Al nuclear spin.

Development of Theory

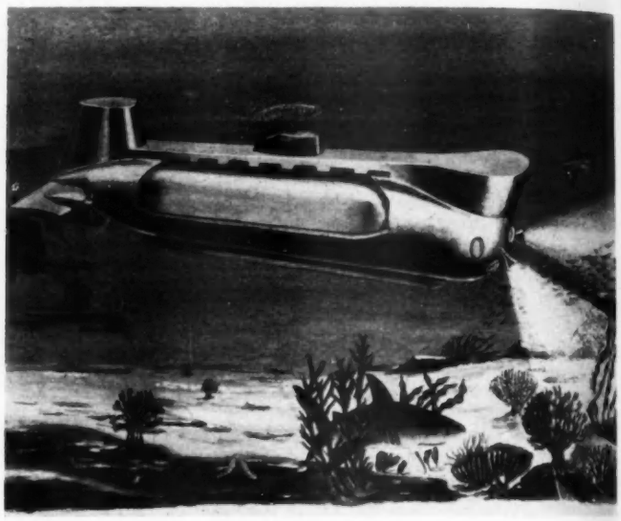
The experimental work has been designed to cover a wide area of physical measurements. In this way investigations form a network of closely connected approaches to the understanding of the electronic and lattice structure of particular solids. To this end, the data provided for the development of new devices and improved engineering materials are complemented by the formulation of theories. For example, experimental studies have resulted in a theory for transport phenomena in a strong magnetic field, and in a better TiO_2 containing vacancies or impurities. Future research in solid-state physics at the Bureau will continue to concentrate on a few materials in working toward more complete data and adequate theories to describe observed phenomena. For example, during the coming years, TiO_2 will receive particular emphasis; electrical, optical, and magnetic investigations of this material will provide valuable information concerning the role of impurities in the conduction mechanism. By studying a single material from several different angles in this way, the Bureau will continue to fulfil its basic function of supplying materials data while also providing a basis for the development of new devices and better engineering materials.

Measurement of nuclear magnetic resonance by placing sample between the pole pieces of a large magnet and connecting it through an oscillator circuit to a chart recorder

Research Submarine of Aluminium Hull Construction

An aluminium research submarine designed to explore the ocean at depths many times beyond the limit of such existing craft is to be built for Reynolds International, Incorporated by the Electric Boat Division of the General Dynamics Corporation, at a cost of 2,000,000 dollars. The Woods Hole Oceanographic Institution will operate the submarine as part of a research programme sponsored by the Office of Naval Research, of the United States Navy. Most of the construction costs incurred by Reynolds will be recovered through the lease of the craft for oceanographic research. Construction of the so-called "Aluminaut" will begin immediately at the Electric Boat Division in Groton, Connecticut, and launching is scheduled for 1963.

Designed to operate at depths of 15,000ft, the "Aluminaut" will permit man to explore about 60 per cent of the world's ocean floor—most of it for the first time. The craft is to be equipped with sonar television cameras for detailed observation of the ocean floor and robot hands to obtain specimens. Displacing 150,000 lb, the "Aluminaut" will be slightly over 50ft long with an 8ft diameter hull. Separate electrical propulsion systems will give the three-man craft both horizontal and vertical locomotion. Its operating range will be about 80 miles. The hull will be constructed by bolting together large, one-piece cylindrical sections of high-strength aluminium forgings. Aluminium was chosen because it is three times lighter than steel and has greater strength for its weight than other available metals. This allows the fabrication of a hull thick enough to withstand tremendous pressures at great depths, yet light enough to stay afloat without external bouyancy.



Artist's impression of the 50ft long "Aluminaut" research submarine to be built for Reynolds International

The Reynolds Metals Company has long been convinced that an important potential for aluminium lies in the field of ship and certain types of submarine hulls. The firm has sponsored this project for two reasons. It feels that it is the duty of private enterprise to promote such programmes in the public interest. Furthermore, the "Aluminaut" will be dramatic proof of the high strength properties of aluminium as a material for ship hulls and other marine applications. The Woods Hole Oceanographic Institution plans to use the "Aluminaut" to extend its capabilities in a wide variety of geological, biological and physical research work on the bottom and in the mid-depths of the ocean. Among the subjects it will study are the submarine canyons, the edge of the continental shelf and the daily vertical migration of marine animals. The "Aluminaut" scheme is the outgrowth of research which has been carried out for several years by the Reynolds Metals Company, the Southwest Research Institute, the General Dynamics Electric Boat Division, the Woods Hole Oceanographic Institution and the U.S. Office of Naval Research.

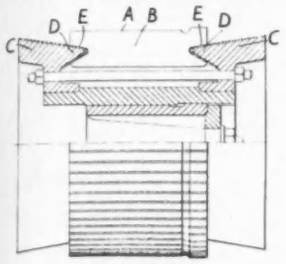
BRITISH PATENT SPECIFICATIONS

The dates printed are those of application and publication on completion. Copies of specifications may be obtained at the Patent Office Sales Branch, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each

ELECTRICAL ENGINEERING

878,013. July 16, 1957.—ELECTRICAL COMMUTATORS, Associated Electrical Industries Ltd., 33, Grosvenor Place, London, S.W.1. (*Inventors : Raymond Thomas Rushall and Norman Leslie George Wilkinson.*)

In the conventional construction of a commutator the segments are clamped endwise between two "V" rings, and it has been the practice to insulate the segments from each ring by means of a pre formed fitting ring of shellac-bonded micanite. This arrangement is generally satisfactory, but in heavy duty or high-speed machines, where the operating



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temperature is high or the centrifugal forces are large, there is a possibility of some of the segments moving outwards a little if the micanite softens. According to the present invention an electrical commutator comprises a plurality of metal segments electrically insulated from one another and clamped endwise between two end rings from which the segments are insulated by electrical insulation consisting only of fibrous glass impregnated with a thermo-hardening synthetic resin. Referring to the drawing a commutator *A* comprises a plurality of copper segments *B* clamped endwise between a pair of end rings *C* having "V"-shaped protuberances *D* co-operating with grooves in the commutator segments. An annular layer *E* of insulation is interposed between the segments and the end rings and comprises preferably woven epoxy resin impregnated glass cloth. The layer may be formed by cutting the cloth to shape and moulding it under the simultaneous action of heat and pressure in a suitably shaped mould to provide the desired configuration. The impregnated glass cloth may advantageously be moulded directly on to the end rings, in which case the latter provide parts of the respective moulds. The moulding of the cloth is preferably carried out before assembling the commutator, but if desired the shaped pieces of impregnated cloth may be inserted between the end rings and the segments and then subjected to heat and pressure to consolidate and harden the resin-impregnated glass cloth. If desired a suitable adhesive may be introduced between the insulation and the segments and end rings to improve the bond.—*September* 20, 1961.

METALLURGY

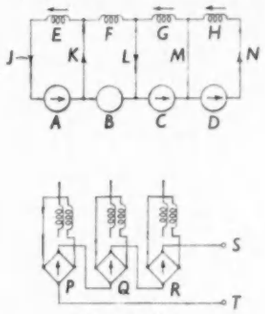
876,723. January 7, 1960.—ALUMINIUM-MANGANESE-IRON ALLOY, Rolls-Royce Ltd., Nightingale Road, Derby. (*Inventors : Jack Raymond Bird, Geoffrey William Meetham and Marcus Alan Wheeler.*)

The object of the invention is to produce alloys of iron with aluminium in the form of bar, sheet and the like which can be made by normal air melting practices, can be worked by normal methods, and which will possess a lower specific gravity than steel but with high impact resistance while retaining an elastic modulus of the same order or value as normal steel. This invention is based upon the discovery that if manganese is added to an iron aluminium alloy in appropriate quantities an alloy can be made which will answer these requirements. There is provided an alloy containing 6–10 per cent by weight of aluminium, 20–40 per cent by weight of manganese, and not more than 0·1 per cent by weight of carbon, the balance being iron and impurities, there being at least 14 per cent by weight more manganese in the alloy than aluminium. Certain other elements may be present in the alloy in replacement for like quantities of iron. Carbon will be present as an impurity of iron to approximately 0·04 per cent. Additional carbon may, however, be added to make the total up to 0·1 per cent. The alloy may contain up to a total of 4 per cent in all of one or more of the following hardening elements : columbium, nickel, cobalt, nitrogen, vanadium, molybdenum, tungsten, silicon, copper. It may also contain up to a total of 0·5 per cent in all of one or more of the following hardening elements : boron, titanium, zirconium. It is stated that alloys according to this invention can be melted in air and should not be melted *in vacuo*. They can be cold worked if required to improve their strength. They may be easily welded and retain their toughness at the weld. They are also readily machinable having a good surface. Their corrosion resistance is much greater than that of mild steel particularly if the alloys are given a light oxidised finish.—*September* 6, 1961.

ELECTRIC TRACTION

877,686. March 1, 1957.—A.C. MOTOR CIRCUIT ARRANGEMENTS, Associated Electrical Industries Ltd., 33, Grosvenor Place, London, S.W.1. (*Inventor : Arthur Mandl.*)

This invention relates to multiple a.c. motor systems and aims at providing an improved circuit arrangement which although not so limited, is particularly advantageous in conjunction with traction drives and where the motors are of a single phase commutator type. When such motors are connected in parallel in order to prevent or reduce wheel slip, the total current may cause difficulties in the supply system on the vehicle. The invention aims at overcoming this difficulty by a circuit arrangement which makes it possible to connect in series several motors, particularly traction motors driving different wheels or wheel pairs. At the same time the individual voltage applied to a motor is independent of voltage changes at other motors, particularly when wheel slip occurs. Referring to the upper



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drawing, traction motors *A* to *D* are connected to four series sections *E* to *H* of a low voltage winding of the transformer through conductors *J* to *N*. Thus with equal sections *E*, *F*, *G*, *H* the terminal voltage of each motor is defined as one quarter of the total voltage across the winding. If wheel slip occurs in connection with motor *B*, the current distribution is as indicated by the arrows, and it will be seen that while the current flowing through motor *B* and section *F* of the transformer winding is reduced to almost zero, this does not affect the values of the current flowing through the motors *A*, *C*, *D* and the winding sections *E*, *G*, *H*. A further advantage is that during normal operation only the outer conductors *J*, *N* carry the full current. The inner conductors normally carry no current and can be constructed with a cross-section for intermittent duty, as required to carry current during the short periods of wheel slip only As shown in the lower drawing, a circuit to detect wheel slip may comprise full wave rectifiers as indicated by the rectifier bridges *P*, *Q*, *R* having their input connected to the secondary windings of current transformers whose primary windings are energised by the inner conductors *K*, *L*, *M*. The d.c. outputs of the rectifiers are connected in series with each other and to terminals *S*, *T*. Under normal operating conditions of the motors there is no signal output, but when wheel slip occurs a substantial d.c. signal appears at the terminals, and a d.c. relay can be connected to these terminals to be energised at a predetermined output from the sensing circuit.—*September* 20, 1961.

GAS TURBINES

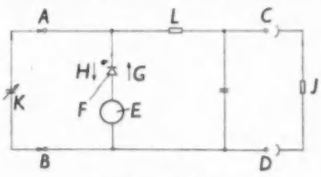
876,734. February 28, 1958.—STARTING MEANS FOR GAS TURBINES, Associated Electrical Industries Ltd., 33, Grosvenor Place, London, S.W.1. (*Inventors : Alexander Grieve, David Vivian Cheney and Ian Gourley Strang.*)

This invention provides a multiple gas turbine starting arrangement comprising a small flash steam boiler, a starter turbine coupled to each gas turbine and a common pressure line with control valves for selective connection between the boiler, starter turbines, and similar pressure stages of the compressors of the gas turbines. The steam producing unit may form a permanent equipment of the gas turbine plant for instance where a self-contained starting system in an aircraft is mandatory. In another embodiment the steam generating plant is mobile, and is preferably carried on a trolley. Advantageously the furnace of the boiler operates with forced draught provided by a fan. This fan may be driven from an electric motor connected to a battery which also supplies the ignition system of the turbine combustion chambers. However, with larger plants it is preferred now to provide an internal combustion engine to drive the boiler water and fuel pumps the fan and a magneto. If the burner of the furnace is constructed to operate on the same fuel as the combustion chambers of the main turbines no separate fuel is needed for the steam generation. With such an arrangement a supply line including stop and control valves also a fuel pump if desired may be arranged between the turbine fuel tank and the starting plant so that no separate container for the boiler fuel is necessary. Typical arrangements of starter equipment to this design are illustrated diagramatically in the specification.—*September* 6, 1961.

ELECTRONICS

877,798. March 26, 1959.—CAPACITIVE CONTROL OF THE MAGNITUDE OF A D.C. VOLTAGE, Standard Telephones and Cables Ltd., Connaught House, 63, Aldwych, London, W.C.2.

For the control of electrical and electrically-controlled mechanical operations it is desirable in certain cases to perform the control not by means of a switch of the conventional type, but by the variation of a physical quantity, without a mechanical switching operation being necessary. The arrangement proposed by the invention does not require an energy conversion, the switching or regulating operation being triggered or controlled by a capacity whose quantity is changed. The circuit shown in the drawing can be regarded as an active nonlinear four-terminal network having input terminals *A* and *B*, and output terminals *C* and *D* and comprising an alternating-current voltage generator *E*, with the angular frequency ω, a rectifier *F* with a forward-resistance *G* and a blocking resistance *H*, and whose output voltage or output current, is dependent not only on the load resistance *J*, but also upon the magnitude of capacitive reactance connected to the input terminals. If a capacitor is connected to the terminals *A*, *B*, or if *K* is enlarged then the latter, in the absence of a terminal resistance *J*, and according



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to the polarisation of the rectifier, will be charged to the positive or negative peak value of the alternating-current voltage supplied by the voltage source *E*. The magnitude of the voltage applied to the output, when loaded with *J* depends upon the ratio J/L and also upon the quantity $L+J$. Furthermore this voltage also depends upon the magnitude of the capacitor *K*, because this determines the time constant of the discharge circuit. Accordingly, it is possible to constitute the variable capacitor by means of a number of fixed capacitors, to deliver a predetermined output voltage, the total value of the capacitance *K* being varied by selecting one or more of the fixed capacitors. It is possible to use as the control capacitance two electrodes, the spaced relation of which is varied, or between which a solid object is moved. For the purpose of measuring the level of a liquid one electrode can be immersed into a liquid, and the other electrode can be arranged above the level of the liquid, in which case the capacity variation is dependent upon the change in level of the liquid. A liquid-level meter of this type has the advantage of requiring no moving parts. Other possibilities of application arise which use the hand capacity of a person to earth to change the value of capacitance of the circuit to earth. Touching of an electrode (terminal *A* in the drawing) is sufficient to obtain a d.c. voltage sufficiently high for control or measuring purposes. Generally speaking it is possible by this arrangement to avoid the use of any mechanical switching operations by simply touching a tuning knob connected to an electrode of the control capacitor.—*September* 20, 1961.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, Nov. 3.—LIVERPOOL AND DISTRICT BRANCH : Industrial Development Centre, M.A.N.W.E.B., Paradise Street, Liverpool, 1, " Current Practice and Recent Trends in Cable Joints and Terminations up to 11kV," H. Flack, 7.30 p.m.

Mon., Nov. 6.—BOLTON BRANCH : Railway Hotel, Trinity Street, Bolton, " Modern Electric Motors and their Control," J. B. Abbot, 7.45 p.m. ★ HALIFAX BRANCH : Griffin Hotel, George Street, Halifax, " The Activities of the E.I.B.A.," J. R. Bardsley, 7.45 p.m. ★ LEEDS BRANCH : Great Northern Hotel, Leeds, " The Application of Photo-electric Cells," A. C. Stewart, 7.30 p.m.

Tues., Nov. 7.—GLOUCESTER AND DISTRICT BRANCH : Royal Hotel, Station Road, Gloucester, " 11kV Jointing and Boxes," 8 p.m. ★ SOUTH EAST LONDON BRANCH : Eltham Green School, Queenscroft Road, Eltham, London, S.E.9, " Earth Resistance and Earth Loop Testing," J. V. Gomersall, 7.45 p.m. ★ WEST LONDON BRANCH : White Hart, 49, Kings Road, Chelsea, London, S.W.3, " Recent Developments in Discharge Lighting," J. J. French, 7.45 p.m. ★ NATIONAL EVENT : Wolverhampton and Staffordshire College of Technology, Wulfruna Street, Wolverhampton, " Electrical Propulsion Devices in Space Flight," L. R. Shepherd, 6.15 p.m. ★ READING AND DISTRICTS BRANCH : East Berks College of Further Education, Boyne Hill Avenue, Maidenhead, " Copper and its Uses," 7.30 p.m.

Wed., Nov. 8.—BIRMINGHAM BRANCH : Engineering and Building Centre, Stephenson Place, Birmingham, 2, " The Kariba Dam Project", M. J. Beard, 7.30 p.m. BRADFORD AND DISTRICT BRANCH : Visit to Dean Smith and Grace, Keighley, 7 p.m. ★ LUTON BRANCH : College of Technology, Park Square, Luton, " Development of Oil-Fired Boiler Control Gear," J. S. Smith, 8.15 p.m.

Thurs., Nov. 9.—BRADFORD AND DISTRICT BRANCH : Midland Hotel, Bradford, " The British Standard Motor," J. L. Browell, 7.30 p.m. ★ NEWCASTLE UPON TYNE AND DISTRICT BRANCH : Visit to the new plate mill of Consett Iron Company Ltd., 7 p.m. ★ SOUTHAMPTON BRANCH : Cathedral Hall, Salisbury, " Electricity in Agriculture," D. W. Holley, 8 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Nov. 8.—MEDICAL ELECTRONICS GROUP : London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, " Electronics in Chromatography," E. L. Gregory and E. A. Piper, 6 p.m. ★ SOUTH WALES SECTION : Welsh College of Advanced Technology, Cardiff, " High Frequency Induction Heating and Dielectric Heating," W. D. Wilkinson, 6.30 p.m. ★ SCOTTISH SECTION : Department of Natural Philosophy, The University, Drummond Street, Edinburgh, Chairman's Address, " Ultra High-Speed Photography," W. A. Jones, 7 p.m. ★ NORTH EASTERN SECTION : Institute of Mining and Mechanical Engineers, Neville Hall, Westgate Road, Newcastle upon Tyne, " A Pulse Time Multiplex System for Stereophonic Broadcasting," G. D. Browne, 6 p.m.

Thurs., Nov. 9.—SCOTTISH SECTION : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, Chairman's Address, " Ultra High-Speed Photography," W. A. Jones, 7 p.m.

Fri., Nov. 10.—SOUTHERN SECTION : College of Technology, Portsmouth, " Recent Advances in Low Noise Microwave Valves," D. G. Kiely, 7 p.m.

COMBUSTION ENGINEERING ASSOCIATION

Tues., Nov. 7.—NORTHERN REGION : Grand Hotel, Leopold Street, Sheffield, " Fuel Selection for Heating Processes in the Steel Industry," 11 a.m.

Wed., Nov. 8.—SCOTTISH REGION : Grand Hotel, Charing Cross, Glasgow, Discussion " The Design and Installation of Industrial Boiler Plants," opened by A. F. Webber, 10 a.m.

ILLUMINATING ENGINEERING SOCIETY

Thurs., Nov. 9.—MANCHESTER CENTRE : Demonstration Theatre, N.W.E.B., Town Hall Extension, Manchester, 2, " Lighting for Christmas," E. P. Lee, 6 p.m.

Mon., Nov. 13.—SHEFFIELD CENTRE : Grand Hotel, Sheffield, " The New I.E.S. Code," H. E. Bellchambers, 6.30 a.m. ★ STOKE-ON-TRENT GROUP : North Stafford Hotel, Stoke-on-Trent, " Lighting Journey down the Rhine," E. J. Smith, 6 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Tues., Nov. 7.—SLOUGH SECTION : Lecture Theatre, High Duty Alloys Ltd., Buckingham Avenue, Slough, " Dust, the Devil and the Doctor," D. G. Macbain, 7.30 p.m.

Thurs., Nov. 9.—BEDS. AND HERTS. SECTION : W. H. Allen Sons and Co. Ltd., Bedford, " Malleable Iron," J. Leishman, 7.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Mon., Nov. 6.—MERSEYSIDE AND NORTH WESTERN SECTION : Liverpool Engineering Society, The Temple, Dale Street, Liverpool, " Observations on the Design and Construction of the N.S. ' Savannah ', " J. A. Dodd and S. Macdonald, 6 p.m. ★ STUDENT LECTURE : Memorial Building, 76, Mark Lane, London, E.C.3, " The First Principles of the Diesel Engine and its Development for Use in Marine Work," G. S. Mole, 6.30 p.m.

Tues., Nov. 7.—JUNIOR LECTURE : East Ham Technical College, Barking Road, London, E.6, " Construction of the Ship," G. Ridley Watson, 7 p.m. ★ DEVON AND CORNWALL SECTION : Technical College, Falmouth, " The Layout and Operation of Marine Steam Turbine Machinery," D. M. V. Parkinson, 8 p.m.

Wed., Nov. 8.—SCOTTISH SECTION : Weir Hall, The Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, " The Development of Heavy Duty Marine Diesels During the Past Five Years," W. Kilchenmann, 7.30 p.m.

INSTITUTE OF METALS

Tues., Nov. 7.—SOUTH WALES LOCAL SECTION : College of Technology, Swansea, Discussion on " Extrusion," and " Hot Extrusion on Non-Ferrous Metals," A. R. E. Singer, 6.30 p.m. ★ OXFORD LOCAL SECTION : Cadena Café, Cornmarket Street, Oxford, " Bearing Materials," P. G. Forrester, 7.15 p.m.

Thurs., Nov. 9.—BIRMINGHAM LOCAL SECTION : College of Advanced Technology, Gosta Green, Birmingham, " The Welding of Metals," D. R. Thorneycroft, 6.30 p.m. ★ EAST MIDLANDS METALLURGICAL SOCIETY : Derby and District College of Art, Derby, " Electron Beam Welding," M. Harper, 7.30 p.m. ★ SOUTHAMPON METALLURGICAL SOCIETY : Evening Visit to Folland Aircraft Ltd.

INSTITUTE OF PETROLEUM

Wed., Nov. 15.—61, New Cavendish Street, London, W.1, Joint meeting with A.S.L.I.B., " The Technologist and his Information Facilities," R. Snel, 5.30 p.m.

INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY

To-day, Nov. 3.—SOUTH WESTERN BRANCH : The University, Exeter, " The Massbauer Effect," G. Lomer, 7 p.m.

Wed., Nov. 8.—LIVERPOOL AND NORTH WALES BRANCH : The University, Liverpool, " The Moon," Z. Kopal, 7 p.m ★ ACOUSTICS GROUP : Imperial College of Science and Technology, South Kensington, London, S.W.7, Half-day symposium on " The Transmission of Vibrations through the Ground," 2 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Tues., Nov. 7.—SOUTH EASTERN BRANCH : Geological Society, Burlington House, Piccadilly, London, W.1, " Underground Gasification of Coal : Part I—General, Part 2—Theory," F. E. Warner, J. Szekely and R. S. H. Mah, 5.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Nov. 7.—Great George Street, Westminster, London S.W.1, Presidential Address, Sir George McNaughton, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

To-day, Nov. 3.—MEDICAL ELECTRONICS DISCUSSION GROUP : Savoy Place, London, W.C.2, Discussion on " Information Theory in Relation to Biology," opened by D. M. Mackey, 6 p.m.

Sat., Nov. 4.—LONDON GRADUATE AND STUDENT SECTION : Visit to Big Ben Clock Tower, 10.30 a.m.

Mon., Nov. 6.—ELECTRONICS AND COMMUNICATIONS SECTION : Savoy Place, London, W.C.2, " The General Problems of F.M. Multi-Channel Communications," R. G. Medhurst, 5.30 p.m. ★ EAST ANGLIAN SUB-CENTRE : College of Arts and Technology, Cambridge, " Are Aircraft Electrics Too Complicated ?" H. Zeffert, 6.30 p.m. ★ NORTH-EASTERN MEASUREMENT AND ELECTRONICS GROUP : Rutherford College of Technology, Northumberland Road, Newcastle upon Tyne, " Micro-miniaturisation," L. T. Ward, 6.15 p.m. ★ SOUTH MIDLAND CENTRE : James Watt Memorial Institute, Birmingham, " A Dynamic Model for Studying the Behaviour of the Overhead Equipment used in Electric Railway Traction," D. S. Farr, H. C. Hall and A. L. Williams, 6.30 p.m.

Tues., Nov. 7.—NORTH-EASTERN CENTRE : College of Further Education, Workington, " Silicon Power Rectifiers," A. J. Blundell, A. E. Garside, R. G. Hibberd and I. Williams, 7 p.m. ★ NORTH MIDLAND CENTRE : Leeds and County Conservative Club, South Parade, Leeds, 1, " Technical and Economic Aspects of the Supply of Reactive Power in England and Wales," W. Casson and H. J. Sheppard, 6.30 p.m. ★ NORTH-WESTERN UTILISATION GROUP : Electrical Engineering (Dover Street) Laboratories, The University, Manchester, " Some Recent Developments in Oscillating Electrical Machines," F. C. Williams, 6.15 p.m. ★ SOUTH-EAST SCOTLAND SUB-CENTRE : Carlton Hotel, North Bridge, Edinburgh, " Brushless Variable-Speed Induction Motors using Phase-Shift Control," F. C. Williams, E. R. Laithwaite, J. F. Eastham and W. Farrer, 7 p.m.

Wed., Nov. 8.—LONDON GRADUATE AND STUDENT SECTION : Visit to Elliott Brothers (London) Ltd., Borehamwood, Herts, 2.30 p.m. ★ NORTH-WESTERN ELECTRONICS AND COMMUNICATIONS GROUP : " Data Transmission," R. H. Franklin and J. Rhodes, 6.15 p.m. ★ NORTH LANCASHIRE SUB-CENTRE : N.W.E.B. Demonstration Theatre, North Road, Lancaster, " The Shielding of Overhead Lines against Lightning," J. H. Gridley, 7.30 p.m. ★ SOUTH-WEST SCOTLAND SUB-CENTRE : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, " Education : Why Bother ?", K. R. Sturley, 6 p.m. ★ SOUTHERN CENTRE : S.E.B. Showrooms, 17, New Canal, Salisbury, " The Protection of High-Voltage Insulators from Power-Arc Damage," A. E. Guile, 6.30 p.m. ★ WESTERN UTILISATION GROUP : S.W.E.B. Demonstration Theatre, Bath, " Silicon Power Rectifiers," A. J. Blundell, A. E. Garside, R. E. Hibberd and I. Williams, 6 p.m. ★ OXFORD DISTRICT BRANCH : Demonstration Room, Southern Electricity Board, 37, George Street, Oxford, " Unconventional Methods of Energy Conversion," P. D. Dunn, 7 p.m.

Wed. to Fri., Nov. 8 *to* 10.—MEASUREMENT AND CONTROL SECTION : Savoy Place, London, W.C.2, Conference on " Non-Destructive Testing in Electrical Engineering," 5.30 p.m.

Thurs., Nov. 9.—NORTH SCOTLAND SUB-CENTRE : Electrical Engineering Department, Queen's College, Dundee, " Thermistors—their Theory, Manufacture and Application," R. W. A. Scarr and R. A. Setterington, 6 p.m. ★ SOUTH-WESTERN SUB-CENTRE : Lecture Theatre, S.W.E.B., Electric House, The Parade, Taunton, " The Application of Electronics to the Electricity Supply Industry," J. S. Forrest, 3 p.m. ★ WEST WALES (SWANSEA) SUB-CENTRE : Electricity Board Showrooms, The Kingsway, Swansea, " A Survey of Street Lighting and its Future," W. R. Stevens and H. M. Ferguson, 6 p.m. ★ NORTH EASTERN GRADUATES' AND STUDENTS' SECTION : Technical College, Sunderland, " F.M. Reception," A. C. Davies, 5.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., Nov. 7.—39, Elmbank Crescent, Glasgow, C.2, Informal Meeting, 6.30 p.m.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS

Tues., Nov. 7.—NORTH EAST COAST BRANCH : Institute of Mining and Mechanical Engineers, Neville Street, Newcastle upon Tyne, " Background to the Industry," B. A. Hodges, 6.30 p.m. ★ SOUTH WEST BRANCH : G.E.C. Building, Cardiff, " Anthracite Fuels for Domestic and Industrial Boilers ? " S. R. Crook, 6.30 p.m.

INSTITUTION OF HIGHWAY ENGINEERS

To-day, Nov. 3.—LONDON BRANCH : Institution of Structural Engineers, 11, Upper Belgrave Street, London, S.W.1, " The Economic Justification of Roads," C. T. Brunner, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Nov. 3.—SCOTTISH BRANCH : Technical College, Dundee, " Closed-cycle Gas Turbine Development for Low-Grade Fuels," W. Connell, 7.30 p.m.

Mon., Nov. 6.—NORTH EASTERN BRANCH : Neville Hall, Westgate Road, Newcastle upon Tyne, " Metallurgy in Relation to Mechanical Engineering," J. A. Brown, 6 p.m. ★ BIRMINGHAM A.D. CENTRE : College of Technology, Gosta Green, Birmingham, " Design and Operation of Motorway Buses," J. Pearson, 6.30 p.m.

Tues., Nov. 7.—AUTOMOBILE DIVISION : Hotel Leofric, Coventry, " A Theory of Brake Squeal," R. T. Spurr, 7.15 p.m. ★ LUBRICATION AND WEAR GROUP : 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on " Refrigeration Lubrication," 6 p.m. ★ NORTH EASTERN BRANCH : Cleveland Scientific and Technical Institute, Corporation Road, Middlesbrough, " Metallurgy in Relation to Mechanical Engineering," J. A. Brown, 6.15 p.m. ★ COVENTRY A.D. CENTRE : Grosvenor Room, Hotel Leofric, Coventry, " A Theory of Brake Squeal," R. T. Spurr, 7.15 p.m. ★ SCOTTISH GRADUATES' SECTION : South Engineering Building, The University, Glasgow, " Raising the German Battle Fleet at Scapa Flow," I. Taylor, 7.30 p.m.

Wed., Nov. 8.—NOMINATED LECTURE : 1, Birdcage Walk, Westminster, London, S.W.1, " Gear-tooth Contact Phenomena," H. E. Merritt, 6 p.m. ★ LUTON A.D. CENTRE : Royal Hotel, Luton, Repetition of Chairman's Address, 7.30 p.m. ★ EAST MIDLANDS GRADUATES' SECTION : College of Technology and Commerce, Leicester, " Mechanisation and Product Control in a Modern Food Factory," E. W. Scarpa, 7.15 p.m. ★ SOUTHERN GRADUATES' SECTION : Technical College, Farnborough, Film Show, 7.30 p.m. ★ SOUTHERN GRADUATES' SECTION : Cockcroft Hall, Harwell, " Spark Erosion Machining," 3.15 p.m.

Thurs., Nov. 9.—EASTERN BRANCH : Gaumont Restaurant, Northampton, Chairman's Address, " Movement in a Ball-Bearing," E. G. Longman, 7.30 p.m. ★ AUTOMATIC CONTROL GROUP : 1, Birdcage Walk, Westminster, London, S.W.1, Brains Trust on " Automatic Control," 6 p.m. ★ NORTH WESTERN BRANCH : College of Science and Technology, Manchester, " Consideration of the Lubrication of Free-Piston Gas Generators," R. M. Hosie and G. M. Barrett, 6.45 p.m. ★ YORKSHIRE GRADUATES' SECTION : Visit to the Aircraft Equipment Division Laboratories, English Electric Company Ltd., Bradford, 4.30 p.m., and " Aircraft Hydraulics Applied to Constant Drive Systems," P. Mooney, 6.45 p.m.

INSTITUTION OF PLANT ENGINEERS

Tues., Nov. 7.—LONDON BRANCH : Royal Society of Arts, John Adam Street, Adelphi, Strand, London, W.C.2, " Pilot-scale Research Work at the D.S.I.R. Warren Spring Laboratory," S. H. Clarke, 7 p.m. ★ PETERBOROUGH BRANCH : White Lion Hotel, Church Street, Peterborough, " Application of Modern Industrial Switch and Control Gear," F. C. Belton, 7.30 p.m.

Wed., Nov. 8.—WESTERN BRANCH : Grand Hotel, Broad Street, Bristol, " Organisation of Planned Maintenance," H. Benford.

Preston, 7.15 p.m.

Thurs., Nov. 9.—GLASGOW BRANCH : Scottish Building Centre, 425, Sauchiehall Street, Glasgow, C.2, " Industrial Air-Conditioning—with particular Reference to Car Body Paint and Spray Plant," V. C. Taylor, 7.15 p.m. ★ NORTH EAST BRANCH : Roadway House, Oxford Street, Newcastle upon Tyne, 1, " Automatic Boiler Control for Medium and Small Size Boilers," 7 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

To-day and Sat., Nov. 3 *and* 4.—Connaught Rooms, London, W.C.2, Fourth Materials Handling Convention, in conjunction with the Institute of Materials Handling. To-day, 2.30 p.m. Sat., 9 a.m.

Sat., Nov. 4.—EAST AND WEST RIDINGS REGION : LEEDS GRADUATE SECTION : Visit to R. W. Crabtree and Sons Ltd., Water Lane, Leeds, 11, 10 a.m. ★ MIDLANDS REGION : COVENTRY GRADUATE SECTION : Visit to Jaguar Cars Ltd., Brown's Lane, Coventry, 9.45 p.m.

Mon., Nov. 6.—SOUTH EASTERN REGION : Royal Aeronautical Society, 4, Hamilton Place, London, W.1., " Cold Forging," F. Griffiths, 7 p.m.

Wed., Nov. 8.—MIDLANDS REGION : Wolverhampton and Staffs. College of Technology, Wolverhampton, " Industrial Research in Britain," P. Spear, 7.15 p.m. ★ NORTH WESTERN REGION : Harris College, Corporation Street, Preston, " Spark Erosion," P. J. C. Gough, 7.30 p.m. ★ SCOTLAND REGION : North British Hotel, Princes Street, Edinburgh, " Flow Turning," E. J. Bennett, 7.30 p.m.

Thurs., Nov. 9.—WOLVERHAMPTON GRADUATE SECTION : Works visit to Talbot Stead Tube Company Ltd., Walsall, Staffs., 2 p.m.

Fri., Nov. 10.—EASTERN REGION : Davey, Paxman and Co. Ltd., Britannia Works Canteen, Colchester, Essex, " Packing," J. E. Evan-Cook, 7.30 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

To-day, Nov. 3.—MIDLAND COUNTIES BRANCH : GRADUATE AND STUDENTS' SECTION : Engineering Centre, Birmingham, " Proposed Bridge over the English Channel," A. R. Flint, 6.30 p.m. ★ SOUTH WESTERN COUNTIES SECTION : Grand Hotel, The Hoe, Plymouth, Chairman's Address, J. D. Norfolk, 6 p.m.

Tues., Nov. 7.—NORTHERN COUNTIES BRANCH : King's College, Newcastle, " What is Structural Engineering ? " P. D. Newton, 6.30 p.m.

Thurs., Nov. 9.—11, Upper Belgrave Street, London, S.W.1, Joint meeting with the Institution of Royal Engineers, " The Development of Engineer Equipment for the Army," H. A. J. Jarrett-Kerr, 6 p.m. ★ WESTERN COUNTIES BRANCH : Queen's Building, University Walk, Bristol, " Engineer Support to the Christmas Island Nuclear Tests of 1958," R. B. Muir, 6 p.m.

Fri., Nov. 10.—SOUTHERN BRANCH : The University, Southampton, Chairman's Address, J. R. Lowe, 6.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Nov. 3.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, Films, " You and the Silicones " ; " Rubber from Rock," and " R. and D.," 7 p.m.

Fri., Nov. 10.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, " Food at Zero," R. M. Cooper, 7 p.m.

LIVERPOOL METALLURGICAL SOCIETY

Thurs., Nov. 9.—Department of Metallurgy, The University, Liverpool, 3, " Metallurgical Aspects in the Development of Fast Fission Reactors," C. R. Tottle, 7 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Fri., Nov. 10.—Mining Institute, Newcastle upon Tyne, " Photo-elasticity and its Application in Marine Engineering Research and Development," J. West and F. S. Lynn, 6.15 p.m.

PLASTICS INSTITUTE

Wed., Nov. 8.—LONDON AND DISTRICT SECTION : Wellcome Building, Euston Road, London, N.W.1, " Plastics in Internally Illuminated Outdoor Signs," J. S. Byers, 6.30 p.m. ★ MIDLANDS SECTION : Grand Hotel, Leicester, " PVC Stabilising Systems," D. Nield and G. D. Rack, 6.45 p.m. ★ SOUTH WALES AND MONMOUTHSHIRE SECTION : Angel Hotel, Cardiff, " New Developments in Flexible Foams," S. B. Cant, 7 p.m.

RADAR AND ELECTRONICS ASSOCIATION

Thurs., Nov. 9.—Lecture Hall, Royal Society of Arts, John Adam Street, Adelphi, London, W.1, " Space Communications," Part 2, " Orbits and their Economics," W. F. Hilton, 7 p.m.

REINFORCED CONCRETE ASSOCIATION

Mon. Nov. 6.—NORTH WESTERN BRANCH : College of Technology, Sackville Street, Manchester, " Code of Practice CP 2007 (1960) Relating to Water Retaining Structures," A. W. Hill, 6.45 p.m.

Tues., Nov. 7.—NORTH WESTERN BRANCH : Liverpool Engineering Society, The Temple, 24, Dale Street, Liverpool, " Code of Practice CP 2007 (1960) Relating to Water Retaining Structures," A. W. Hill, 6.30 p.m.

Wed., Nov. 8.—LONDON BRANCH : Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2, " Shrinkage and Creep in Concrete," A. M. Neville, 6 p.m.

ROYAL INSTITUTION OF NAVAL ARCHITECTS

To-day, Nov. 3.—Institute of Marine Engineers, 76, Mark Lane, London, E.C.3, Joint Symposium on " Welding in Shipbuilding," sponsored by The Institute of Welding, The Royal Institution of Naval Architects, The Institution of Engineers and Shipbuilders in Scotland, The North East Coast Institution of Engineers and Shipbuilders and The Institute of Marine Engineers.

ROYAL SOCIETY

Thurs., Nov. 9.—BAKERIAN LECTURE : Burlington House, Piccadilly, London, W.1, " Sound Generated Aerodynamically," M. J. Lighthill, 4.30 p.m.

ROYAL SOCIETY OF ARTS

Thurs., Nov. 9.—John Adam Street, Adelphi, London, W.C.2, " New Developments in the Use of Solar Energy," Harold Heywood, 5.15 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Mon., Nov. 6.—CONTROL SECTION : Manson House, 26, Portland Place, London, W.1, " Semiconductor Diodes and Rectifiers in Control Engineering," P. R. Wyman and " The Transistor in Control Engineering," G. D. Bergman, 6.30 p.m.

WEST OF SCOTLAND IRON AND STEEL INSTITUTE

Thurs., Nov. 16.—39, Elmbank Crescent, Glasgow, Junior Members' Night, Papers on " Marking, Cutting and Testing of Steel," 6.45 p.m.

WOMEN'S ENGINEERING SOCIETY

Wed., Nov. 8.—" Hope House," 45, Great Peter Street, Westminster, London, S.W.1, " Windmills—Their Rise and Decline," R. Wailes, 7 p.m.